Fixed Ground Antenna Radome (FGAR) Type I/III OT&E Integration and OT&E Operational Final Test Report

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May 1995

DOT/FAA/CT-TN95/23

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Atlantic City Airport, NJ 08405

technical note

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-TN95/23		

4. Title and Subtitle	5. Report Date
FIXED GROUND ANTENNA RADOME (FGAR) TYPE I/III OT&E INTEGRATION AND OT&E OPERATIONAL FINAL TEST REPORT	May 1995
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Leonard H. Baker, ACT-310B; Harold G. Sedgwick, Raytheon	DOT/FAA/CT-TN95/23
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405	11. Contract or Grant No.
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405	Technical Note
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This test report documents the Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing performed on the Type I/III, Fixed Ground Antenna Radome (FGAR). The Type I/III FGAR is used with the Air Route Surveillance Radar (ARSR)) -1/2 and AN/FPS military radars.

The testing was performed at the Federal Aviation Administration (FAA) Technical Center's Elwood En Route Beacon Test Facility (ERBTF) and the Northwest Mountain Region's Trinidad En Route Radar Facility (TAD), Colorado. The testing included: (1) characterization of the primary and secondary radar's electromagnetic performance, (2) human factors, (3) physical characteristics, and (4) physical performance.

The electromagnetic performance testing showed no degradation of the primary or secondary radars; there were no human factor problems found; and only minor problems were identified during the physical characteristics and physical performance tests. The testing determined that the FGAR meets the Operational Suitability and Operational Effectiveness requirements of the FAA.

17. Key Words	18. Distribution Statement
Fixed Ground Antenna Radome (FGAR) Operational Test and Evaluation (OT&E) Integration Operational	Document is on file at the Technical Center Library, Atlantic City International Airport, NJ 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	177	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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EXECUTIVE SUMMARY

Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing of the Type I/III Fixed Ground Antenna Radomes (FGAR) was performed at the Federal Aviation Administration (FAA) Technical Center's En Route Beacon Test Facility (ERBTF), Elwood, New Jersey (NJ), and the Northwest Mountain Region's Trinidad En Route Radar Facility (TAD), Colorado (CO). Testing at the Elwood ERBTF was performed during the period August 15 to December 6, 1994. Testing at the Trinidad En Route Radar Facility was performed during the period October 3 to November 25, 1994.

FGAR OT&E Integration and OT&E Operational testing included: (1) characterization of the primary and secondary radar's electromagnetic performance, (2) human factors, (3) physical characteristics, and (4) physical performance.

Electromagnetic performance testing was accomplished in several ways: (1) comparative measurements were made between the original inflatable radome and the FGAR using the Mode Select Beacon System (Mode S) at the Technical Center's Elwood ERBTF, (2) the Northwest Mountain Region's Radio Frequency (RF) Interference Monitoring (RFIM) van was used to make comparative horizontal and vertical solar measurements between the original radome and the FGAR, (3) the Albuquerque (ZAB) and Denver (ZDV) Air Route Traffic Control Center's (ARTCC) compared Trinidad En Route Radar Facility (TAD) data received before and after the FGAR was installed, and (4) Air Traffic Control Specialists (ATCS) at the Albuquerque (ZAB) and Denver (ZDV) ARTCCs evaluated the Trinidad En Route Radar Facility (TAD) video data on their displays. In addition, the Northwest Mountain Region's Establishment Engineering Branch, ANM-450, had a flight check performed.

Human factor tests verified that the access hatches did not present a constraint to individuals wearing heavy winter clothing and there were no electrical hazards. The physical characteristics tests verified nameplates and labels were present on the radome and its subassemblies. The physical performance tests verified there was adequate transient protection provided to prevent transients from entering the facility electrical or signal systems.

The electromagnetic performance testing showed no primary or secondary radar electromagnetic performance degradation; there were no human factor problems found; and only minor problems identified during the physical characteristics and physical performance tests. These problems should not delay deployment of the FGAR, but should be corrected during production or installation, as appropriate.

In conclusion, OT&E testing determined that the FGAR meets the Operational Suitability and Operational Effectiveness requirements of the FAA. The FGAR is ready to be integrated into the National Airspace System (NAS).

1. INTRODUCTION.

1.1 PURPOSE.

The purpose of this report is to provide the results of the Operational Test and Evaluation (OT&E) Integration and Operational testing accomplished on the Type I/III Fixed Ground Antenna Radomes (FGAR) installed, at the Federal Aviation Administration (FAA) Technical Center's Elwood, New Jersey (NJ) En Route Beacon Test Facility (ERBTF) and the Northwest Mountain Region's Trinidad En Route Radar Facility (TAD), Colorado (CO), both of which are considered to be First Article sites.

1.2 SCOPE.

OT&E testing was conducted at two locations: the Technical Center's Elwood ERBTF was selected because it had an En Route Mode Select Beacon System (Mode S) and the Northwest Region's Trinidad En Route Radar Facility (TAD) because it was a National Airspace System (NAS) regional facility with operational interfaces and environmental conditions that allowed the completion of OT&E testing on the first subsystem prior to the Deployment Readiness Review (DRR) deployment decision.

The Northwest Mountain Region's Establishment Engineering Branch, ANM-450, scheduled a flight check of the Trinidad En Route Radar Facility (TAD). The results of the flight check are included in this report.

The following tests were performed:

a. Electromagnetic performance.

   1. Elwood ERBTF.

      Utilizing the En Route Mode S, Air Route Surveillance Radar (ARSR) -2, AN/UPX-27 Beacon System, and Common Digitizer (CD) -2.

   2. Trinidad En Route Radar Facility (TAD).

      (a) Utilizing the Air Traffic Control Beacon Interrogator (ATCBI) -3, ARSR-2, and CD-2.

      (b) Albuquerque (ZAB) and Denver (ZDV) Air Route Traffic Control Center (ARTCC) Quick Analysis of Radar Sites (QARS) program analysis.

      (c) Albuquerque ARTCC (ZAB) Range, Azimuth, Radar Reinforcement Evaluator (RARRE), Beacon False Target Analysis (BFTA), and Common Digitizer Data Reduction (COMDIG) programs analysis.

      (d) Albuquerque (ZAB) and Denver (ZDV) ARTCC Air Traffic Control Specialist (ATCS) evaluation.

      (e) Aircraft flight check.

b. Human engineering.

c. Physical characteristics.

d. Physical performance.

2. REFERENCE DOCUMENTS.

2.1 FAA ORDERS.

Order 6050.32	Spectrum Management Regulations and Procedures Manual
Order 6100.1C	Maintenance of NAS En Route Stage A - Air Traffic Control System
Order 6365.3	Maintenance of the Mode Select (Mode S) Beacon System
Order OA P 8200.1	United States Standard Flight Inspection Manual

2.2 FAA SPECIFICATIONS.

FAA-E-2716	Mode Select Beacon System (Mode S) Sensor
FAA-E-2773b	Fixed Ground Antenna Radome (Mode S Compatible)
FAA-E-2835	Environmental Remote Monitoring Subsystem (ERMS)

2.3 OTHER FAA DOCUMENTS.

FAA-4306B-6H	User's Manual - Common Digitizer Data Reduction (COMDIG) Program
FAA-4306F-3H	User's Manual - Common Digitizer Record (CD Record) Program
FAA-4306M-6H	User's Manual - Range, Azimuth, Radar Reinforcement Evaluator (RARRE) Program
FAA-4306N-7H	User's Manual - Quick Analysis of Radar Sites (QARS) Program
FAA-4306P-9H	User's Manual Beacon False Target Analysis (BFTA) Program
SPB-TRA-009	New Radar Analysis Software for the Transportable Radar Analysis Computer System
DOT/FAA/CT-TN93/17	Test and Evaluation Master Plan (TEMP) for Fixed Ground Antenna Radomes (FGAR)
DOT/FAA/CT-TN94/63	Operational Test and Evaluation (OT&E) Integration and Operational Test Plan for Fixed Ground Antenna Radome (FGAR)
DOT/FAA/CT-TN94/65	Operational Test and Evaluation (OT&E) Integration and Operational Test Procedures for Fixed Ground Antenna Radome (FGAR)

2.4 FAA FIELD TEST REPORTS.

ATCS Evaluation Questionnaire, FGAR OT&E Operational Test, Form FGAR-2AB. Questionnaires completed by Air Traffic Control Specialists (ATCS) at the Albuquerque ARTCC (ZAB), Undated

Leone, Andrew, ACW-100B "REPORT - FGAR Mode S OT&E Testing at the Technical Center's Elwood ERBTF." Report prepared for Associate Program Manager for Test (APMT), ACW-100B, January 31, 1995

Manager, Albuquerque ARTCC AFS (ZAB) "Trinidad (TAD) Long Range Radar Radome Replacement Evaluation." Report prepared for Associate Program Manager for Test (APMT), ACW-100B, December 8, 1994

Manager, Denver ARTCC (ZDV) "Trinidad Radar Questionnaire" Memorandum to Air Traffic Manager, ANM-500, January 5, 1995

Manager, Denver ARTCC AFS (ZDV) "Evaluation of Radar Data From Trinidad, CO, ARSR." Report prepared for Associate Manager for Test (APMT), ACW-100B, December 22, 1994

Ulm, Jim, ANM-464I "Radome Replacement Tests, Trinidad, Colorado." Report prepared for Manager, ANM-464, Technical Support Section, Northwest Mountain Region, November 11, 1994

Ulm, Jim, ANM-464I "Radome Replacement Tests, Trinidad, Colorado." Report prepared for Manager, ANM-464, Technical Support Section, Northwest Mountain Region, March 29, 1995

Walsh, Steve, ANM-450E3 "Flight Check Report - Trinidad, Colorado, ARSR-2, ATCBI-3." Report undated

2.5 U.S. GEOLOGICAL SURVEY (USGS) MAPS.

Lockwood Arroyo Quadrangle, Las Animas County, Colorado, Scale 1:24,000, 7.5 Minute Series (Topographic), 1972 (Photorevised 1984)

Thatcher Quadrangle, Las Animas County, Colorado, Scale 1:24,000, 7.5 Minute Series (Topographic), 1970

3. SYSTEM DESCRIPTION.

3.1 MISSION REVIEW.

The FAA program to implement the En Route Mode S resulted in a requirement to replace the existing radomes at en route radar and beacon-only-site (BOS) facilities. The existing radomes are not physically large enough to accommodate the En Route Mode S back-to-back antennas. The FGAR supplies optimal protection of the antennas from the outside environment while providing minimal degradation to the electromagnetic performance characteristics of the enclosed antennas.

3.2 TEST SYSTEM CONFIGURATION.

The Type I/III FGAR provides an optimal environmental enclosure for a collocated L-band surveillance radar reflector and top-mounted back-to-back L-band beacon phased array antennas. The radome is capable of withstanding wind velocities of 150 miles per hour (MPH). They have an inside diameter of 59 feet at their widest point, and will fit a base ring diameter equal to the present CW-396A radome. The Type I/III FGAR is used with the ARSR-1/2 and AN/FPS-type surveillance radars.

The radome is supplied as a complete assembly, which includes:

a. Lightning protection subsystem (LPS).

b. Zenith Service and Catwalk Access Hatches.

c. Aircraft obstruction light (AOL) assembly.

d. Devices to monitor the state of the AOLs and the access hatches condition (open/closed).

3.3 INTERFACES.

The Type I/III FGAR interfaces both mechanically and electrically with NASs. A block diagram of the interfaces is shown in figure 3.3-1.

3.3.1 Mechanical.

The Type I/III FGAR interfaces mechanically with the existing antenna tower radome base ring.

3.3.2 Electrical.

The Type I/III FGAR interfaces electrically with the antenna tower/facility:

a. Electrical system

b. LPS

c. Remote Maintenance Monitoring System (RMMS)/Environmental Remote Monitoring Subsystem (ERMS)

3.3.3 Interface Testing.

a. Mechanical.

The mechanical interface between the FGAR antenna tower/CW-396A radome base ring was completely tested during on-site Design Qualification Test (DQT) testing.

b. Electrical.

1. The interface between the FGAR and the facility electrical system was completely tested.

2. The interface between the FGAR and the antenna tower LPS was completely tested during on-site DQT testing.

3. The interface between the FGAR and the RMMS/ERMS could not be tested, since the ERMS has not been developed yet. The FGAR side of the interface, however, was tested against the requirements of specification FAA-E-2835.

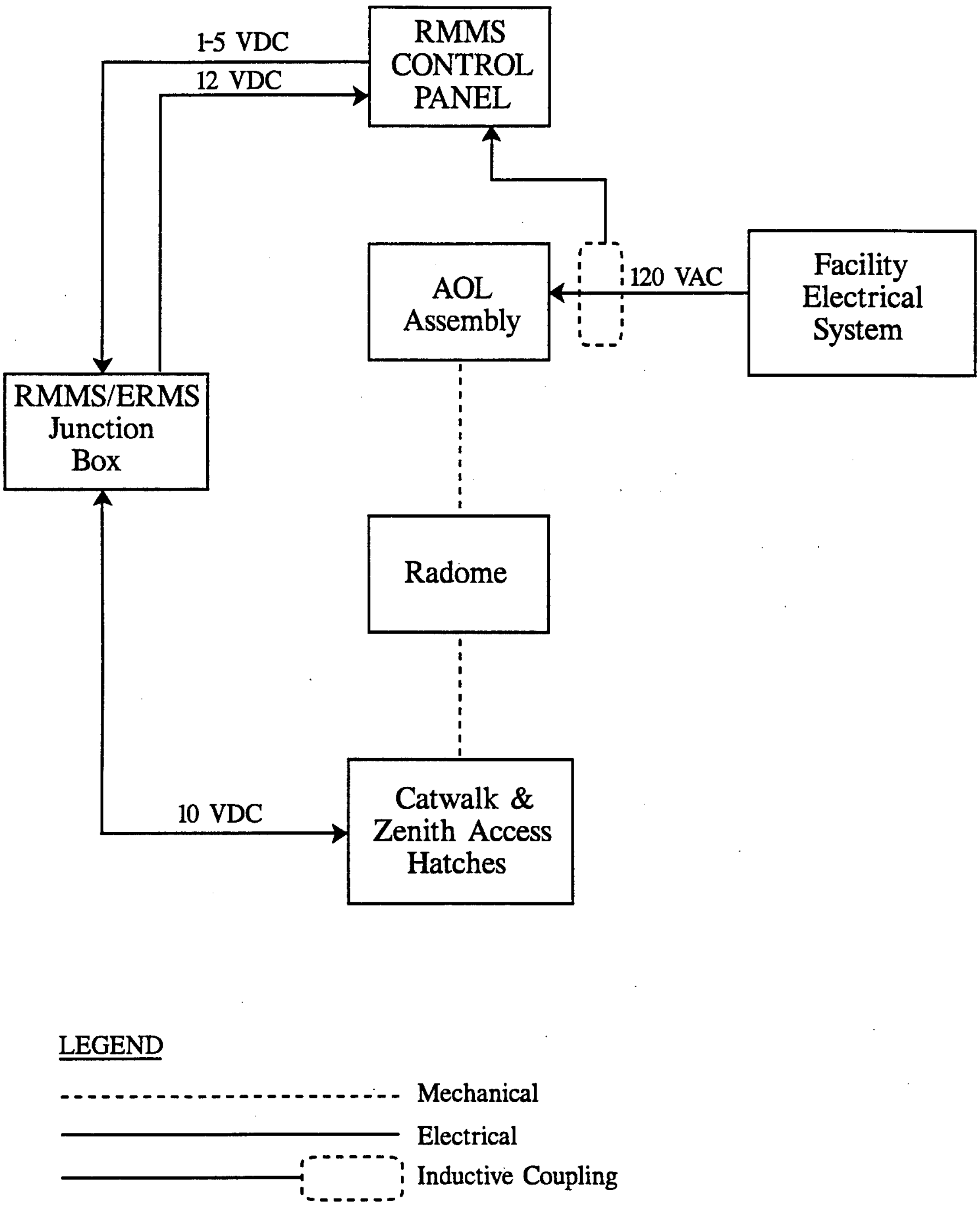


FIGURE 3.3-1 FGAR INTERFACES BLOCK DIAGRAM

4. TEST AND EVALUATION DESCRIPTION.

4.1 TEST SCHEDULE AND LOCATIONS.

a. Elwood ERBTF.

Testing at the Technical Center's Elwood ERBTF was performed during the period of August 15 to December 6, 1994.

b. Trinidad En Route Radar Facility (TAD).

Testing at the Trinidad En Route Radar Facility (TAD) was performed during the period of October 3 to November 25, 1994.

4.2 PARTICIPANTS.

The test participants included personnel from a several different organizations and contractors (appendix A contains a list of the individual test participants). The organizations and contractors participating were:

a. En Route Radar Engineering Division, ANR-800

b. Secondary Surveillance Systems Division, ACW-100

c. Maintenance Engineering Branch, ANM-464

d. Albuquerque ARTCC (ZAB)

e. Albuquerque ARTCC (ZAB) Airway Facilities Sector (AFS)

f. Denver ARTCC (ZDV)

g. Denver ARTCC (ZDV) AFS

h. MiTech/ACW-100B

i. Raytheon/ACW-100B

j. Vitro/En Route Surveillance Radar, ANR-400

k. Electronic Space Systems Corporation (ESSCO)

4.3 TEST AND SPECIALIZED EQUIPMENT.

The following Government furnished equipment (GFE) was used to perform the tests:

a. Elwood ERBTF.

1. The installed ARSR-2, En Route Mode S, AN/UPX-27 Beacon System, and CD-2.
2. Mode S Analysis Recording Display Equipment (MARDE).
3. Real-Time Analysis Display System (RTADS).
4. Radar and Beacon Performance Analysis programs.
5. Miscellaneous test equipment, e.g., oscilloscope, digital multimeter (DMM), +12 volt (V) direct current (DC) power supply, etc.

b. Trinidad En Route Radar Facility (TAD).

1. The installed ARSR-2, ATCBI-3, and CD-2.

2. Northwest Mountain Region's Radio Frequency (RF) Interference Monitor (RFIM) van ("Born-Free", license number DOT32723).

3. Albuquerque (ZAB) ARTCC HOST computer systems and the QARS, RARRE, BFTA, and COMDIG programs.

4. Denver (ZDV) ARTCC HOST computer system and QARS program.

5. Miscellaneous test equipment, e.g., oscilloscope, DMM, +12V DC power supply, etc.

All of the test equipment used was in calibration. The Trinidad En Route Radar Facility (TAD) was not decertified during the FGAR installation. The Albuquerque (ZAB) and Denver (ZDV) ARTCCs were certified operational facilities.

5. ELECTROMAGNETIC PERFORMANCE TESTS.

Electromagnetic performance testing was divided between the Technical Center's Elwood ERBTF and the Northwest Mountain Region's Trinidad En Route Radar Facility (TAD).

The electromagnetic performance testing was conducted under good, dry weather conditions, with the exception of 1 day's testing at the Technical Center's Elwood ERBTF which was performed after 2 days of rain.

5.1 ELWOOD ERBTF.

5.1.1 Mode S Electromagnetic Performance Tests.

a. Objective.

The objective was to collect Mode S data, using the Calibration Performance Monitoring Equipment (CPME) and the output of the CD-2, with the inflatable radome, without a radome, and with the FGAR installed. To analyze the data and compare it to determine if the FGAR degraded the performance of the Mode S.

b. Criteria.

The difference(s) measured between the Mode S electromagnetic performance parameters with the inflatable radome, without a radome, and with the FGAR installed, if any, do not exceed the following:

1. Main beam width change of ±0.05° maximum.

2. Boresight error 0.0085° root-mean-square (RMS) and 0.0255° maximum, in either the elevation (vertical) or azimuth (horizontal) plane.

3. Sidelobe level error of ±1 decibel (dB), using a sidelobe that is -25 dB below the main lobe of reference, for all frontal and back lobes.

4. Azimuth pointing accuracy of the Mode S antenna is not degraded.

c. Description.

Mode S electromagnetic performance data were collected, analyzed, and compared using the programs available at the Technical Center (see appendix B), to evaluate the following:

1. Beacon false targets.

2. Distribution of monopulse values.

3. Range and azimuth accuracy of fixed targets.

4. Beacon and search performance parameters.

The critical issue is: Does the FGAR degrade the electromagnetic performance of the Mode S antenna pattern?

5.1.2 Data Collection and Analysis Method.

Data were recorded with the inflatable radome installed, without a radome, and again after the FGAR was installed. The data were normally collected in the morning, between 0700 and 0900 hours local time. The collection periods consisted of a minimum of 200 scans.

The data were collected by three different methods:

a. Mode S/MARDE.

Mode S data were collected via the MARDE. This data consisted of all interrogations, target replies and reports, surveillance track file data, and dissemination data.

b. Mode S/RTADS.

Mode S dissemination data were collected by the RTADS, in CD-2 format, at the Mode S modem port.

c. CD-2/RTADS.

The CD-2 output data were collected by the RTADS, using the ARSR-2 and either the Mode S in Interim Beacon Initiative (IBI) mode or the AN/UPX-27 Beacon System.

Upon completion of testing, ACW-100 engineers analyzed the data recorded, using the analysis programs available at the Technical Center (see appendix B). They compared the inflatable radome data, to no radome installed data, to the FGAR installed data.

5.1.3 Results and Discussion.

The effect of the FGAR on the electromagnetic performance of the Mode S and AN/UPX-27 Beacon System installed at the Elwood ERBTF was evaluated. The Mode S was tested in the beacon-only configuration since the Mode S to CD-2 interface was not available.

The data recorded without a radome installed showed greater errors than with either the inflatable or the FGAR installed. The increase in the amount of the errors can only be attributed to wind loading on the radar antennas. A

similar situation occurred during testing at the Trinidad En Route Radar Facility (TAD).

The results of the individual analysis programs are discussed in the following paragraphs.

5.1.3.1 Beacon False Target Summary.

After the FGAR was installed, the false beacon target percentages showed an average decrease of 0.15 percent. There is no established national standard for the percentage of false beacon targets. See table 5.1.3.1-1.

The percentages for split targets, ring-around, uplink and downlink reflections, and pulse repetition frequency (PRF), are with in the nominal tolerances defined in FAA Order 6365.3. There is no established national standard for "Other" errors. See tables 5.1.3.1-2 through 5.1.3.1-7.

	Total False Targets	Total Target Reports	False Target %
Inflatable	318.4	60077.7	0.51
FGAR	211.2	60390.0	0.36

TABLE 5.1.3.1-1 AVERAGE BEACON FALSE TARGETS

Nominal <0.2%	Total	%
Inflatable	19.1	0.03
FGAR	8.7	0.01

TABLE 5.1.3.1-2 AVERAGE SPLIT TARGETS

Nominal <1.0%	Total	%
Inflatable	0.0	0.00
FGAR	0.3	0.00

TABLE 5.1.3.1-3 AVERAGE RING-AROUND

Nominal <1.0%	Total	%
Inflatable	0.3	0.00
FGAR	0.8	0.00

TABLE 5.1.3.1-4 AVERAGE DOWNLINK REFLECTIONS

Nominal <1.0%	Total	%
Inflatable	1.0	0.00
FGAR	5.3	0.08

TABLE 5.1.3.1-5 AVERAGE PRF

Nominal <1.0%	Total	%
Inflatable	1.1	0.00
FGAR	1.3	0.08

TABLE 5.1.3.1-6 AVERAGE UPLINK REFLECTIONS

	Total	%
Inflatable	170.3	0.16
FGAR	115.8	0.19

TABLE 5.1.3.1-7 AVERAGE OTHER ERRORS

5.1.3.2 Monopulse Analysis.

The monopulse accuracy was measured using the Mode S CPMEs, whose location is accurately known. After installation of the FGAR, there was no degradation of the Mode S azimuth accuracy across the antenna beam. The Mode S azimuth accuracy remained within the 0.068° RMS required by specification FAA-E-2716.

5.1.3.3 Nine Point Analysis.

A summary of the Nine Point Analysis, totals were used as an overall means of evaluating the tracking data. Data were collected from the: (1) Mode S, (2) CD-2 with the Mode S operating in the IBI mode, and (3) CD-2 with the AN/UPX-27 Beacon System.

To provide the greatest accuracy the targets were filtered using the Radar Beacon Analysis Tool (RBAT) program. The targets selected had a range of 5 to 200 nautical miles (NM), an azimuth of 0° to 360°, an altitude of 5,000 to 50,000 feet, and a elevation angle of 0.5° to 35°. The targets were both Mode S and Air Traffic Control Radar Beacon System (ATCRBS), with a radial or tangential flight path, had a high detection code reliability and confidence, and were not climbing/descending or performing any other maneuvers. Specification FAA-E-2716 specifies a maximum allowable azimuth error of 0.068° RMS.

a. Range.

The range error improved very slightly after the FGAR was installed. There was a 0.3 percent improvement with the Mode S, and a 1.1 percent improvement with the CD-2

operating with either the Mode S in IBI mode or the AN/UPX-27 Beacon System. The average range errors are shown in table 5.1.3.3-1.

	Range Error (NM)		
	Mode S	Mode S IBI	AN/UPX-27
Inflatable	0.0439	0.0448	0.0446
FGAR	0.0438	0.0438	0.0441

TABLE 5.1.3.3-1 AVERAGE RANGE ERRORS

b. Azimuth.

The azimuth error was degraded slightly after the FGAR was installed. There was a 7.8 percent degradation of the Mode S and the CD-2 operating with the Mode S in IBI mode, and a 9.1 percent degradation with the CD-2 operating with the AN/UPX-27 Beacon System. The errors do not exceed the 0.068° RMS maximum specified by specification FAA-E-2716. See table 5.1.3.3-2.

	Azimuth Error (°)		
	Mode S	Mode S IBI	AN/UPX-27
Inflatable	0.0524	0.1589	0.1421
FGAR	0.0565	0.1465	0.1551

TABLE 5.1.3.3-2 AVERAGE AZIMUTH ERRORS

5.1.3.4 Surveillance Analysis.

The average total probability of detection (PD) and altitude reliability and confidence levels were improved for the Mode S and ATCRBS after the FGAR was installed. The PD improved by 0.06 percent, the altitude reliability by 0.31 percent, and the altitude confidence by 0.44 percent. The identification (ID) reliability and confidence levels, however, were degraded by 0.14 percent and 0.10 percent, respectively.

The majority of the parameters were improved by the FGAR installation. The amount the two parameters were degraded is insignificant.

5.1.3.5 Fruit Analysis.

The average Mode S and ATCRBS fruit levels measured after the FGAR was installed were lower. There was approximately a 22 percent decrease in the Mode S and a 5 percent decrease in the ATCRBS fruit level. The changes in fruit levels were attributed to the random nature of fruit and the limited number of data samples. The average fruit levels are shown in table 5.1.3.5-1.

	Fruit Level	
	Mode S	ATCRBS
Inflatable	515.1	884.8
FGAR	401.3	840.8

TABLE 5.1.3.5-1 AVERAGE FRUIT LEVEL

5.2 TRINIDAD EN ROUTE RADAR FACILITY (TAD).

The Trinidad En Route Radar Facility (TAD) electromagnetic performance testing was divided between testing performed at the site and the Albuquerque (ZAB) and Denver (ZDV) ARTCCs.

5.2.1 Trinidad En Route Radar Facility (TAD) Site Tests.

5.2.1.1 Primary (ARSR) and Secondary (ATCRBS) Radar Electromagnetic Performance Tests.

a. Objective.

The objective was to collect primary (ARSR) and secondary (ATCRBS) radar electromagnetic performance data to determine if the: (1) main beam width, (2) boresight error, (3) sidelobe level error, changed, if any.

b. Criteria.

The difference(s) measured between the primary (ARSR) and secondary (ATCRBS) radars electromagnetic performance parameters, without a radome installed and with the FGAR installed, if any, do not exceed the following:

1. Maximum main beam width change of ±0.05°.

2. Boresight error of 0.0085° RMS and 0.0255° maximum, in either the elevation or azimuth plane.

3. Sidelobe level error change of ±1 dB, using a sidelobe that is -25 dB below the main lobe of reference, for all frontal and back side lobes.

c. Description.

The testing measured electromagnetic parameters included in specification FAA-E-2773b which were not tested during Design Qualification Testing (DQT).

Primary (ARSR) and secondary (ATCRBS) electromagnetic performance data were collected, analyzed, and compared using the RFIM van and its programs.

The critical issue is: Does the FGAR degrade the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS) antenna patterns?

5.2.1.2 Data Collection and Analysis Method.

The primary (ARSR) and secondary (ATCRBS) radars azimuth (horizontal) electromagnetic performance parameters were measured by ANM-464 engineers, using their RFIM van. The measurements were made from three locations approximately 120° apart, around the antenna tower (see appendix C). The use of a Global Positioning System (GPS) receiver allowed them to locate the van in exactly the same location each time.

The primary (ARSR) and secondary (ATCRBS) radars elevation (vertical) measurements were made by tracking the sun at sunrise and again at sunset as described in Chapter 17, Radar Antenna Pattern Measurement by Solar Means, FAA Order 6050.32.

The data were collected and analyzed by programs available in the RFIM van. The ANM-464 engineers compared the original radome data, to no radome data, to the FGAR installed data.

5.2.1.3 Results and Discussion.

Solar measurements were used to measure the elevation (vertical) plane electromagnetic performance parameters, using the sun as a source of RF energy. A comparison of the data recorded with no radome installed to that with the FGAR installed, showed no measurable difference.

The horizontal plane data collected without a radome installed were erratic due to wind loading. The results of the horizontal plane electromagnetic performance parameter measurements were:

a. Antenna Main Lobe Beam Width Change.

The average measured 3 dB beam width of the original radome was 1.58°, the FGARs average measured beam width was 1.55°. The change in the antenna main lobe beam width was 0.03°, which is within the specified tolerance.

b. Boresight Error.

The measured boresight error with the original radome and the FGAR were identical.

c. Sidelobe Level Error Change.

The difference between no radome and with the FGAR installed was 0.78 dB, which is within the specified tolerance.

5.2.2 ARTCC QARS Program Tests.

The ARTCCs collect data from all radar facilities supplying data to their facilities and analyze it using their HOST computer system and the QARS program (see appendix B). The QARS program output data are used to determine if the data from the radar facilities is usable for air traffic control (ATC).

The Trinidad En Route Radar Facility (TAD) supplies data to both the Albuquerque (ZAB) and Denver (ZDV) ARTCCs. The Albuquerque (ZAB) and Denver (ZDV) ARTCCs supported the OT&E Operational testing by analyzing the QARS output data for a period of time prior to the removal of the original radome to the data received after the FGAR was installed. The Technical Support Staff (TSS)/Technical Support Office (TSO) engineers at the respective ARTCCs forwarded the output data to the Technical Center for analysis.

a. Objective.

The objective was to determine if there were any difference(s) in the performance characteristics of the primary (ARSR) and secondary (ATCRBS) radar data received by the ARTCCs after the FGAR was installed.

b. Criteria.

The primary (ARSR) and secondary (ATCRBS) radar performance characteristics measured at the ARTCC by the QARS program are not degraded by the FGAR.

c. Description.

The Albuquerque (ZAB) and Denver (ZDV) ARTCCs ran the QARS program on their HOST computer system using primary (ARSR) and secondary (ATCRBS) data from the Trinidad En Route Radar Facility (TAD).

The critical issue is: Does the FGAR degrade the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS) radars?

d. Data Collection and Analysis Method.

A representative sampling of QARS data have been tabulated. In addition, the secondary radar (ATCRBS) PD (same as Blip/Scan ratio), the Mode 3/A validity (Mode 3/A Val.), and Mode C validity (Mode C Val.) have been graphed. These data are presented in appendix D.

e. Results and Conclusions.

The parameters measured by the QARS program were within established national standards as defined in FAA Order 6100.1C.

5.2.2.1 Denver ARTCC (ZDV) QARS Program Test.

a. Data Collection and Analysis Method.

The Denver ARTCC (ZDV) TSO Staff Engineers analyzed the QARS data for the period of October 9 through November 15, 1994, excluding the 10 days when the radars were shutdown for installation of the FGAR.

Their analysis was directed towards the critical parameters, e.g., blip scan ratio, search reinforcement, azimuth splits, range splits, Mode 3/A and Mode C validity and reliability, etc. They also queried the personnel operating the Systems Maintenance Monitor Console (SMMC) and the ATCSs.

Upon completion of running the QARS program on the original radome data and with the FGAR installed, the TSO engineers compared the data to determine if there were any change(s) in the accuracy of the data or any other anomalies.

b. Results and Conclusions.

The TSO staff engineers concluded the installation of the FGAR did not have any noticeable effect on the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS) radars.

5.2.3 Albuquerque ARTCC (ZAB) Tests.

a. Objective.

The objective was to determine if there were any difference(s) in the measured performance characteristics of the primary (ARSR) and secondary (ATCRBS) radar data being received by the ARTCC after the FGAR was installed.

b. Criteria.

The performance characteristics of the primary (ARSR) and secondary (ATCRBS) radar reinforced radar, beacon false targets, and CD-2 data being received by the ARTCC are not degraded by the FGAR.

c. Description.

The Albuquerque ARTCC (ZAB) ran the (1) RARRE, (2) BFTA, and (3) COMDIG analysis programs on their HOST computer system (see appendix B). Data from the Trinidad En Route Radar Facility (TAD) primary (ARSR) and secondary (ATCRBS) radars, were used.

The critical issue is: Does the FGAR degrade the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS) radars?

d. Data Collection and Analysis Method.

The data analyzed by the RARRE, BFTA, and COMDIG programs was collected for a period of several hours each time, while the primary (ARSR-2) and secondary (ATCBI-3) radars were operating on the same channels.

Upon completion of running the RARRE, BFTA, and COMDIG programs on the original radome data and with the FGAR installed, the TSS engineers compared the data to determine if there were any change(s) in the data or other anomalies.

e. Results and Discussion.

The results of the RARRE, BFTA, and COMDIG programs were:

1. RARRE.

The overall results of the radar reinforcement analysis were somewhat varied, some parameters were better while others were worse.

(a) The overall radar reinforcement was 64 percent with the original radome and 62 percent with the FGAR.

(b) Radar reinforcement in the 50 to 105 NM range was 70 percent with the original radome and 60 percent with the FGAR installed.

(c) On either side of the 50 to 105 NM range band, the percentages were higher with the FGAR installed.

(d) Altitude and range plots showed the radar coverage was 1,000 to 2,000 feet worse with the FGAR installed.

(e) The radar range coverage was reduced from 187 NM with the original radome installed to 185 NM with the FGAR installed.

The overall radar reinforcement percentage reduction may have been caused by small differences in the aircraft traffic patterns at the time the data were recorded.

2. BFTA.

There was a reduction of 0.001 percent in beacon false targets after the FGAR was installed, which is statistically insignificant. The different types of beacon target splits were approximately the same with the original radome when compared to the FGAR, except there were fewer ring-around targets after the FGAR was installed.

3. COMDIG.

En route radar facilities have at least one fixed beacon transponder, referred to as a "parrot", located several miles from the facility. The location of these "parrots" is precisely known and they are used to evaluate the en route radar ATCRBS.

With the original radome installed, nine percent of the "parrot" replies fell outside the two azimuth change pulse (ACP) limit. After the FGAR was installed, only one "parrot" reply out of 1,500 replies (0.067 percent) was outside the two ACP limit.

The TSS engineers who evaluated the data concluded the changes were so slight that they would have no effect on ATC, especially since some of the changes were an improvement.

5.2.4 ARTCC ATCS Evaluation Tests.

Questionnaires were forwarded to the Albuquerque (ZAB) and Denver (ZDV) ARTCCs requesting that journeyman ATCSs, who normally operate displays using Trinidad En Route Radar Facility (TAD) video data, complete them. The questionnaires were divided into three sections: (1) primary radar evaluation, (2) secondary (beacon) radar evaluation, and (3) overall evaluation. The purpose was to determine if the user, the ATCSs, could see any change(s) between the video data displayed with FGAR installed as compared to the original radome.

a. Objective.

The objective was to determine if there were any difference(s) in the primary (ARSR) and secondary (ATCRBS) video data presented to the ATCSs, e.g., apparent strength of targets, loss of targets, or other anomalies, with the FGAR installed as compared to the original radome.

b. Criteria.

The primary (ARSR) and secondary (ATCRBS) video data strength appeared the same to the ATCSs. The number of lost/coasting targets did not increase. There were no other apparent anomalies.

c. Description.

The Albuquerque ARTCC (ZAB) ATCSs who normally operate displays using Trinidad En Route Radar Facility (TAD) primary (ARSR) and secondary (ATCRBS) video data completed a questionnaire.

The critical issue is: Does the FGAR degrade the primary (ARSR) or secondary (ATCRBS) radar video data?

5.2.4.1 Albuquerque ARTCC (ZAB) ATCS Evaluation Test.

a. Data Collection and Analysis Method.

After the questionnaires were completed, they were forwarded by the ARTCC Air Traffic (AT) Plans and Program Section to the Test Director (TD).

b. Results and Discussion.

A total of 30 questionnaires were returned. The responses are tabulated in appendix E. The percentages shown are based on the number of respondents to each question.

1. Part I - Primary Radar Evaluation.

The majority of the ATCSs responses indicated the primary (ARSR) radar was unaffected by the installation of the FGAR.

2. Part II - Secondary (Beacon) Radar Evaluation.

The majority of the ATCSs responses indicated the secondary (ATCRBS) radar was unaffected by the installation of the FGAR. However, six (20.7 percent) of the respondents referred to "speed fluctuations" or "speed changes" in their written comments.

3. Part III - Overall Evaluation.

The majority of the ATCSs responses indicated the overall performance was unaffected by the installation of the FGAR. However, three (11.3 percent) of the respondents referred to "speed fluctuation" or "speed changes" in their written comments.

5.2.4.2 Denver ARTCC (ZDV) ATCS Evaluation Test.

a. Data Collection and Analysis Method.

The ARTCC Manager had the video data evaluated and submitted a report describing the results of the evaluation. The questionnaires were not returned.

b. Results and Discussion.

The ARTCC Airspace and Procedures specialists held discussion sessions with the ATCSs in lieu of completing the questionnaires. The results of these discussions were:

1. The video data appears the same to the ATCSs.

2. There has been no reported increase in the incidence of ring-around, false targets, or beacon code swapping, or other anomalies.

5.2.5 Flight Check.

The Northwest Mountain Region's Establishment Engineering Branch, ANM-450, scheduled a flight check to be performed after the FGAR was installed and the facility was operational. The flight check was performed in two phases:

a. Inbound.

The inbound phase was flown at an altitude of 15,000 feet mean-sea-level (MSL) in a northeasterly direction (57.1° true North) towards the site. The aircraft was first detected at a range of 133.1 NM and tracked until reaching the cone of silence (an area over the site where the target is lost) at 2.04 NM.

b. Orbital Coverage.

The orbital coverage phase was flown at an altitude of 8,000 feet MSL, at a range of 10 NM, from an azimuth of 327° to 322°. Primary radar racking was lost when the radar receiver moving target indicator (MTI) filters detected no radial velocity. The ATCBI-3 tracked the aircraft during the complete orbit.

c. Data Collection and Analysis Method.

Three methods were used to collect data during the flight check: (1) QARS data was recorded at the Denver ARTCC (ZDV), (2) manual scoring at the Denver ARTCC (ZDV) was used to record the whether the primary (ARSR) and secondary (ATCRBS) video data was present on the ATCS displays, and (3) raw CD-2 output data displayed at the Trinidad En Route Radar Facility (TAD) was manually recorded by site personnel.

The QARS data was analyzed using the Common Digitizer Record (CDRECORD) program and the PLOTCD program was used to plot the data.

The manual scoring at the Denver ARTCC (ZDV) was performed by observing whether the primary or secondary radar target video data was presented on an operational Plan View Display (PVD) display.

d. Results and Discussion.

The following is based on an analysis of the CD-2 and manually scored data recorded at the Denver ARTCC (ZDV).

1. There was no unexpected jitter, drop-outs, or holes (areas where a target is lost) observed that were considered significant during the inbound phase.

2. There was no significant change in the number of beacon false or ring-around targets observed, that might indicate unusual or irregular attenuation, or signal scattering from the radome joints.

3. The FGAR exhibits a negligible effect on the effectiveness of the primary (ARSR) or secondary (ATCRBS) radars.

6. HUMAN ENGINEERING TESTS.

The human engineering tests were divided into two parts: (1) clothing constraints, and (2) electrical. These tests were performed at the Elwood ERBTF.

6.1 CLOTHING CONSTRAINTS TESTS.

a. Objective.

To verify the configuration of the radome access hatches does not present a constraint to personnel, wearing heavy winter clothing, when passing through the hatches. The access hatches latches could be operated by an individual wearing heavy winter gloves.

b. Criteria.

1. Zenith Hatch Assembly mounted equipment can be serviced, repaired, removed, and/or replaced by individuals wearing heavy winter clothing, e.g., parka, insulated suit, heavy winter gloves, etc.

2. An individual can pass through the Catwalk Access Hatch in either direction, with ease, while wearing heavy winter clothing, e.g., parka, insulated suit, heavy winter gloves, etc.

3. Latches used to open the Zenith Service and Catwalk Access Hatches are designed to allow an individual wearing heavy winter gloves to operate them. The latches can be latched/unlatched from either the inside or outside of the radome.

c. Description.

1. The Zenith Hatch Assembly was inspected to verify there is sufficient clearance available for an individual wearing heavy winter clothing, e.g., parka, insulated suit, etc., to service, repair, and/or remove equipment mounted on the Zenith Crown Plate. In addition, the hatch latch handle could be operated while wearing heavy winter gloves.

2. The Catwalk Access Hatch was inspected to verify there is sufficient clearance available for an individual wearing heavy winter clothing, e.g., parka, insulated suit, etc., to pass through in either direction. In addition, the hatch latch could be operated from either side while wearing heavy winter gloves.

There were no critical issues involved in these tests.

d. Data Collection and Analysis Method.

The test data were recorded on a FGAR-3, HECT-1/2/3 Clothing Constraints Test Data Sheet form. The TD analyzed the data to verify the Zenith Service and Catwalk Access Hatches allowed an individual wearing heavy winter clothing to pass through. In addition, that the hatch latches could be operated by an individual wearing heavy winter gloves.

e. Results and Discussion.

There were no problems found during the tests. The hatches were sufficiently large for an individual, wearing heavy winter clothing, to pass through in either direction. An individual wearing heavy winter gloves could operate the hatch latches.

6.2 ELECTRICAL TESTS.

a. Objective.

To verify the electrical equipment is designed and provided with safety features to prevent personnel injury.

b. Criteria.

1. The circuit breaker (CB), terminal boards (TB), etc., with 30V alternating current (AC) RMS or DC, or greater present during normal operation have covers, shrink tubing, etc., to protect personnel from accidentally contacting current carrying parts.

2. Caution labels are affixed to doors or other means of access to equipment with 30V AC RMS or DC, or greater present during normal operation.

3. The CB is provided with a means of locking it in the open (de-energized) position.

c. Description.

1. The CB, TBs, etc., with 30V AC RMS or DC, or greater present during normal operation, were inspected to verify they have covers, shrink tubing, etc., to protect personnel from accidentally contacting current carrying surfaces.

2. Electrical cabinets, boxes, etc., with 30V AC RMS or DC, or greater present during normal operation, were inspected to verify CAUTION labels were affixed to doors or other means of access.

3. The CB was inspected to verify it was provided with a means of locking it in the open (de-energized) position.

There were no critical issues involved in these tests.

d. Data Collection and Analysis Method.

The test data were recorded on a FGAR-4, HEET-1/2/3 Electrical Test Data Sheet form. The TD analyzed the data to verify current carrying terminals, etc., are covered to protect against accidental contact, the CB can be locked in an open (de-energized) position, a 120V CAUTION label was present on the RMMS Control Panel door, and there were no other electrical hazards.

e. Results and Discussion.

There were no problems found during the tests. The design of the RMMS Control Panel provides protection against personnel accidently contacting current carrying parts and provides a means of locking the CB in the open (de-energized) position. Electrical connections in the radome are enclosed in weather tight electrical

boxes. A "120V" caution label is located on the RMMS Control Panel door.

7. PHYSICAL CHARACTERISTICS TESTS.

The Nameplate and Labeling Tests were the only physical characteristics tests performed. These tests were performed at the Elwood ERBTF.

a. Objective.

To verify assemblies and components, e.g., aircraft obstruction light (AOL) assembly, cables, CB, TBs, etc., were correctly, permanently, and legibly labeled.

b. Criteria.

1. Assemblies, e.g., AOL assembly, etc., had a nameplate with the equipment title, designation, and serial number (if applicable) displayed. The nameplate information was:

   (a) Recorded in a permanent and legible manner, which would not be affected by weather, etc.

   (b) Permanently affixed to the assembly.

   (c) Visible, without having to disassemble or remove any parts, covers, etc.

2. The cables, CB, TBs, etc., were correctly, permanently, and legibly labeled with their appropriate designation, value, or other descriptive information, e.g., ON/OFF for CB position, etc., as appropriate.

c. Description.

1. Assemblies, e.g., AOL, etc., were inspected to verify they had a nameplate with the equipment title, designation, and serial number (if applicable) displayed. The nameplate information:

   (a) Was recorded in a permanent, legible manner, which is unaffected by weather, etc.

   (b) Was permanently affixed to the assembly.

   (c) Was visible without having to disassemble and/or remove any parts, covers, etc.

2. The cables, CB, TBs, etc., were inspected to verify they were permanently and legibly labeled with their appropriate designation, value, and/or other descriptive information.

There were no critical issues involved in these tests.

d. Data Collection and Analysis Method.

The test data were recorded on a FGAR-1, PCNP-1/2 Nameplate/Labeling Test Data Sheet form. The TD analyzed the data to determine if all required nameplates, labels, etc., were present.

e. Results and Discussion.

Two problems were found during the testing.

1. The RMMS Control Panel did not have an FA-type number nameplate attached to the outside of the door.

2. The Zenith Service and Catwalk Access Hatches RMMS open/closed monitor switches were not labeled with their designation.

FGAR-9, Test Discrepancy Report (TDR) forms were prepared.

8. PHYSICAL PERFORMANCE TESTS.

The Transient Protection Tests were the only physical performance tests performed. These tests were performed at both the Elwood ERBTF and the Trinidad En Route Radar Facility (TAD).

a. Objectives.

1. To verify the facility electrical and signal systems are protected from induced electrical transients entering through the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable, AOL power cable, or the RMMS Control Panel AOL Adjustable Linear Current Sensor.

2. To verify the RMMS Control Panel AOL Adjustable Linear Current Sensor is not falsely triggered by induced electrical transients.

b. Criteria.

1. There are no induced electrical transients present on the Zenith Service/Catwalk Access Hatch RMMS open/closed monitor cable when measured at the output (facility side) of the RMMS Control Panel.

2. There are no induced electrical transients on the AOL power cable when measured at the input (facility side) of the RMMS Control Panel.

3. There are no induced electrical transients in the output of the AOL Adjustable Linear Current Sensor when measured at the output (facility side) of the RMMS Control Panel.

4. The RMMS Control Panel AOL Adjustable Linear Current Sensor is not falsely triggered by induced electrical transients.

c. Description.

1. The Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable was monitored for induced electrical transients at the output (facility side) of the RMMS Control Panel, with an oscilloscope.

2. The AOL power cable was monitored for induced electrical transients, at the input (facility side) of the RMMS Control Panel, with an oscilloscope.

3. The output of the AOL Adjustable Linear Current Sensor was monitored for induced electrical transients, at the output (facility side) of the RMMS Control Panel, with an oscilloscope.

4. The output of the AOL Adjustable Linear Current Sensor was monitored at the RMMS Control Panel, with a DMM, to verify it was not being falsely triggered by induced electrical transients.

There were no critical issues involved in these tests.

d. Data Collection and Analysis Method.

The test data were recorded on FGAR-5, PPTP-1/2/3/4 Transient Protection Test Data Sheet forms. The TD analyzed the data to determine if:

1. There were any transients present on the Zenith Service/Catwalk Access Hatch RMMS open/closed monitor cable, the AOL power cable, or the output of the RMMS Control Panel AOL Adjustable Linear Current Sensor.

2. The AOL Adjustable Linear Current Sensor was not falsely triggered by electrical transients.

e. Results and Discussion.

Problems were found at both the Elwood ERBTF and the Trinidad En Route Radar Facility (TAD). The problems were similar, but of different magnitudes.

1. Elwood ERBTF.

(a) A 40 V peak-to-peak (P-P) [28.3 V RMS], 60 Hertz (Hz), level was found on the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable at the output of the RMMS Control Panel (facility side), with AOL power applied. When AOL power was turned off, the level dropped to 4.3 V P-P (3.0 V RMS).

The AOL power cable and the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable are run in the same conduit between the radar equipment building and the antenna tower platform. The conduit is terminated in a common junction box on the antenna tower platform.

The cables share the same square duct, within the radar equipment building, with many other facility electrical and signal cables. Within the radome, the cables are secured together with cable ties, from the antenna tower platform to the zenith.

(b) There were no RF transients found on either cable. The Mode S was operating at full power, however, the ARSR-2 was operating with the magnetron only. The amplitron could not be operated due to equipment problems.

2. Trinidad En Route Radar Facility (TAD).

(a) A 17 V P-P (12.0 V RMS), 60 Hz, level was found on the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable at the output of the RMMS Control Panel (facility side), with AOL power applied. When AOL power was turned off, the level dropped to 650 millivolts (mV) P-P (460 mV RMS).

The AOL power cable and the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable are run in separate conduits between the radar equipment building and the antenna tower platform. The conduits are terminated in separate junction boxes on the antenna tower platform.

The cables share the same square duct, within the radar equipment building, with many other facility electrical and signal cables. Within the radome, the cables are secured together with cable ties, from the antenna tower platform to the zenith.

(b) There were 100 mV peak RF transients present on the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable at the output of the RMMS Control Panel (facility side).

(c) There were 200 mV peak RF transients present at the output of the RMMS Control Panel AOL Adjustable Linear Current Sensor.

The transients were apparently fed down the AOL power cable and passed through the AOL Adjustable Linear Current Sensor circuitry and transient suppressor.

The ATCBI-3 was operating at full power and the ARSR-2 was operating at full power, with the amplitron.

The 60 Hz levels, induced into the Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable, will vary from site to site due to the routing of the cable though the same square duct and cable troughs in the radar equipment building, etc. The RF transient levels should remain relatively constant since the amount of cable exposed to RF energy should be approximately the same.

The same level of induced 60 Hz and RF transients were found on both sides of the RMMS Control Panel transient protectors. The ERMS will interface directly with the output of these transient protectors.

FGAR-9, Test Discrepancy Report (TDR) forms were prepared.

9. CONCLUSIONS.

9.1 DQT TESTING.

The Functional Configuration Audit (FCA) uncovered one test issue still open. Paragraph 3.2.1, FAA-E-2773b, requires all electromagnetic performance parameters be met while operating under the environmental conditions listed in

paragraph 3.2.5, FAA-E-2773b. The environmental condition are:

a. High and low ambient temperatures

b. Relative humidity

c. Altitude

d. Salt atmosphere

e. Maximum wind speed

f. Maximum operating snow or ice load

g. Hail impact

There has been no electromagnetic performance testing under the environment conditions specified in paragraph 3.2.5, FAA-E-2773b. The FGAR DQT electromagnetic performance testing was performed under dry conditions, near sea level, and at room temperature. OT&E Operational testing was performed in dry conditions, near sea level and at approximately 5000 feet altitude, and at temperatures ranging between 60° and 90° Fahrenheit (°F).

9.2 OT&E OPERATIONAL TESTING.

Based upon the results of OT&E Integration and Operational testing, the following conclusions about the Type I/III FGAR can be drawn:

a. The FGAR does not degrade the electromagnetic performance of the primary (ARSR) or secondary (ATCRBS and Mode S) radars.

b. The FGAR does not present any safety hazards or problems to personnel who must maintain it.

c. The RMMS Control Panel needs an FA-type number label installed,

d. The Zenith Service and Catwalk Access Hatches RMMS open/closed monitor switches need to be labeled.

e. The Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable and the AOL Adjustable Linear Current Sensor RMMS Control Panel transient protectors do not eliminate or reduce the induced 60 Hz levels or RF transients. The 60 Hz levels and/or RF transients could degrade the operation or damage the ERMS, when it is installed.

10. RECOMMENDATIONS.

The results of OT&E Integration and OT&E Operational testing uncovered no major problems with the Type I/III FGAR. The FGAR meets the Operational Suitability and Operational Effectiveness requirements of the FAA. It is recommended that the FGAR's be integrated into the NAS.

It is recommend that the following minor discrepancies be corrected:

a. An FA-type number label be affixed to the RMMS Control Panel door.

b. The Zenith Service and Catwalk Access Hatches RMMS open/closed monitor switches be labeled with their designation.

c. The RMMS Control Panel Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable and the AOL Adjustable Linear Current Sensor transient protectors be replaced with a type that will eliminate RF transients and 60 Hz.

d. The Zenith Service/Catwalk Access Hatches RMMS open/closed monitor cable and the AOL power cable:

   1. Be run in separate conduits between the radar equipment building and the antenna tower platform.

   2. Be terminated in separate junction boxes on the antenna tower platform.

   3. Be separated as widely as possible, within the radome.

e. An Engineering Change Proposal (ECP) be generated that addresses the electromagnetic performance parameters not tested while operating under the environmental conditions specified in paragraph 3.2.5, FAA-E-2773b.

11. ACRONYMS AND ABBREVIATIONS.

°	Degree(s)
>	Greater Than
<	Less Than
#	Number
%	Percent(age)
AC	Alternating Current
ACP	Azimuth Change Pulse(s)
AFS	Airway Facilities Sector
AN/UPX	Army-Navy/General Utility Radar Identification and Recognition (military designation)
AOL	Aircraft Obstruction Light(s)
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
AT	Air Traffic
ATC	Air Traffic Control
ATCBI	Air Traffic Control Beacon Interrogator
ATCRBS	Air Traffic Control Radar Beacon System
ATCS	Air Traffic Control Specialist
AZ	Azimuth (QARS program)

BCN	Beacon (QARS program)
BFTA	Beacon False Target Analysis (a computer program)
CB	Circuit Breaker
CD	Common Digitizer
CDRECORD	Common Digitizer Record (a computer program)
CO	Colorado
COLL	Collimation (QARS program)
COMDIG	Common Digitizer Data Reduction (a computer program)
CPME	Calibration Performance Monitoring Equipment
dB	Decibel
DC	Direct Current
DEG	Degree(s)
DEV	Deviation (QARS program)
DMM	Digital Multimeter
DQT	Design Qualification Test(ing)
DRG	Data Receiver Group
DRR	Deployment Readiness Review
ECP	Engineering Change Proposal
ERBTF	En Route Beacon Test Facility
ERMS	Environmental Remote Monitoring Subsystem
ESSCO	Electronic Space Systems Corporation (company name)
F	Fahrenheit
FAA	Federal Aviation Administration
FCA	Functional Configuration Audit
FGAR	Fixed Ground Antenna Radome
GFE	Government Furnished Equipment
GPS	Global Positioning System
HOST	Air Traffic Control HOST Computer System (not an acronym)
Hz	Hertz
IBI	Interim Beacon Initiative
IBM	International Business Machines (company name)

ID	Identification
LOG/NML	Logarithmic Normal (QARS program)
LPS	Lightning Protection Subsystem
MA	Massachusetts
MARDE	Mode S Analysis Recording Display Equipment
Mode S	Mode Select Beacon System
MSL	Mean Sea Level
MTI	Moving Target Indicator
mV	Millivolt
NAS	National Airspace System
NJ	New Jersey
NM	Nautical Mile
NML	Normal (QARS program)
NO.	Number
OT&E	Operational Test and Evaluation
P-P	Peak-to-Peak
PC	Personal Computer
PD	Probability of Detection
PE	Permanent Echo (QARS program)
PRF	Pulse Repetition Frequency
PVD	Plan View Display
QARS	Quick Analysis of Radar Sites (a computer program)
RARRE	Range, Azimuth, Radar Reinforcement Evaluator (a computer program)
RBAT	Radar Beacon Analysis Tool (a computer program)
REFL	Reflection(s)
REL	Reliability (QARS program)
RF	Radio Frequency
RFIM	Radio Frequency Interference Monitoring
RMMS	Remote Maintenance Monitoring System
RMS	Root-Mean-Square
RNG	Range (QARS program)

RPTS	Reports
RTADS	Real-Time Analysis Display System
SCH/BCN	Combined Moving Target Indicator and Normal Video/Beacon (QARS program)
SEC	Second(s)
SMMC	Systems Maintenance Monitor Console
TAD	Trinidad En Route Radar Facility (identifier)
TB	Terminal Board
TD	Test Director
TDR	Test Discrepancy Report
TGT	Target(s)
TGTS	Targets
TRACS	Transportable Radar Analysis Computer System
TSO	Technical Support Office
TSS	Technical Support Staff
TX	Texas
V	Volt(s)
VAL	Validity
ZAB	Albuquerque Air Route Traffic Control Center (identifier)
ZDV	Denver Air Route Traffic Control Center (identifier)

APPENDIX A

TEST PARTICIPANTS

TEST PARTICIPANTS

The personnel, and their organization, who participated in the individual tests are listed below:

1. Elwood ERBTF.

   a. Mode S Electromagnetic Performance Tests.

   Andrew Leone, Electronic Engineer, ACW-100B

   George Montgomery, Engineer, MiTech/ACW-100B

   b. Human Engineering - Clothing Constraints Tests.

   Michael Freie, Electronic Engineer, ANR-800

   Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B

   Leonard Schrock, Senior Field Service Supervisor, Electronic Space Systems Corporation (ESSCO)

   Ken Romanwiz, Field Service Technician, ESSCO

   c. Human Engineering - Electrical Tests.

   Michael Freie, Electronic Engineer, ANR-800

   Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B

   d. Physical Characteristics - Nameplate/Labeling Tests.

   Michael Freie, Electronic Engineer, ANR-800

   Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B

   e. Physical Performance - Transient Protection Tests.

   Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B

2. Trinidad En Route Radar Facility (TAD).

   a. Primary Radar Electromagnetic Performance Tests.

   Harry J. Gardner, Spectrum Management Officer, ANM-464J

   James L. Ulm, Spectrum Management Officer, ANM-464I

   b. ATCRBS Electromagnetic Performance Tests.

   Harry J. Gardner, Spectrum Management Officer, ANM-464J

   James L. Ulm, Spectrum Management Officer, ANM-464I

   c. Albuquerque ARTCC (ZAB) QARS Program Tests.

   Staff Engineers, TSS, Albuquerque ARTCC (ZAB) AFS

   d. Denver ARTCC (ZDV) QARS Program Tests.

   Staff Engineers, TSO, Denver ARTCC (ZDV) AFS

e. <u>Albuquerque ARTCC (ZAB) ATCS Evaluation Test</u>.

ATCSs, Albuquerque ARTCC (ZAB)

f. <u>Denver ARTCC (ZDV) ATCS Evaluation Test</u>.

ATCSs, Denver ARTCC (ZDV)

g. <u>Physical Performance - Transient Protection Tests</u>.

Harold G. Sedgwick, Senior Engineer, Raytheon/ACW-100B

Jeffrey L. Hobbs, Senior Engineer, Vitro/ANR-400

APPENDIX B

DATA ANALYSIS PROGRAMS

DATA ANALYSIS PROGRAMS

1. Technical Center.

The programs used at the Technical Center to analyze the electromagnetic performance of the Elwood ERBTF secondary radar (Mode S) were:

a. Beacon False Target Summary - Analyzes false beacon targets in azimuth, i.e., target splits, ring around, and uplink and downlink reflections. The uplink reflections are used to calculate the location and orientation of the reflectors. Range versus azimuth, range versus altitude, and azimuth versus altitude plots are provided for the false targets. The program also provides a plot of the reflections.

b. Monopulse Analysis - Analyzes the distribution of monopulse values for a stationary target. Plots of monopulse versus antenna azimuth, azimuth error versus antenna azimuth, absolute value of azimuth error versus antenna azimuth, mean and standard deviation, the Mode S Sensor monopulse table, and scatter plots of the raw data points are provided.

c. Nine Point Analysis - Analyzes the range and azimuth accuracy of the target reports for a given target. The reference range and azimuth positions are determined using a nine point curve fit centered on the target report of interest.

d. Surveillance Analysis - Analyzes beacon and search performance for all beacon tracks. Statistics are provided individually for each track and combined into ATCRBS, Mode S, and total categories. Range versus azimuth, range versus altitude, and azimuth versus altitude plots are provided which contain track initiations, coasts, and drops.

e. Fruit Analysis - Calculates the ATCRBS and Mode S fruit rates coming into the Mode S Sensor. Statistics are given for each sector and combined into totals for all the sectors. These statistics are provided every minute for the duration of the filter time interval. The fruit rates are tabulated and plotted.

f. Mode S Extraction Plot - Plots replies and reports from a Mode S extraction file.

g. Radar Beacon Analysis Tool (RBAT) - Similar to the Nine Point Analysis program, except CD-2 data is used.

2. Northwest Mountain Region RFIM Van Programs.

The commercial software programs used by the Northwest Mountain Region's RFIM van to analyze the electromagnetic performance of the Trinidad En Route Radar Facility (TAD) primary (ARSR) and secondary (ATCRBS) were:

a. LabWindows, Version 2.1 - National Instruments, Inc., Austin, Texas (TX).

b. EasyPlot for Windows, Version 2.2 - Spiral Software, Inc., Brookline, Massachusetts (MA).

3. ARTCC Computer Programs.

The programs used at the ARTCCs to analyze the electromagnetic performance of Trinidad En Route Radar Facility (TAD) primary (ARSR) and secondary (ATCRBS) data were:

a. Quick Analysis of Radar Sites (QARS) - The QARS program provides confirmation of an ARTCCs CD interface and operational status. The data can be either real time or a CDRECORD format tape. The QARS program is run on the HOST computer system.

b. Range, Azimuth, Radar Reinforced Evaluator (RARRE) - The RARRE program provides the capability to retrieve, sort, and print target information pertaining to all Mode 3/A beacon equipped aircraft detected by any number of radar sites. The data are received from a CDRECORD format tape. The RARRE program is run on the HOST computer system.

c. Beacon False Target Analysis (BFTA) - The BFTA program is a tool to investigate and evaluate the false target problem in the NAS automated ATCRBS radar system. The BFTA program is run on the HOST computer system.

d. Common Digitizer Data Reduction (COMDIG) - The COMDIG program extracts selected types of data from a CDRECORD program tape containing various mixtures of the six CD message types received by the HOST computer system and prints the data in the prescribed formats. The COMDIG program is run on the HOST computer system.

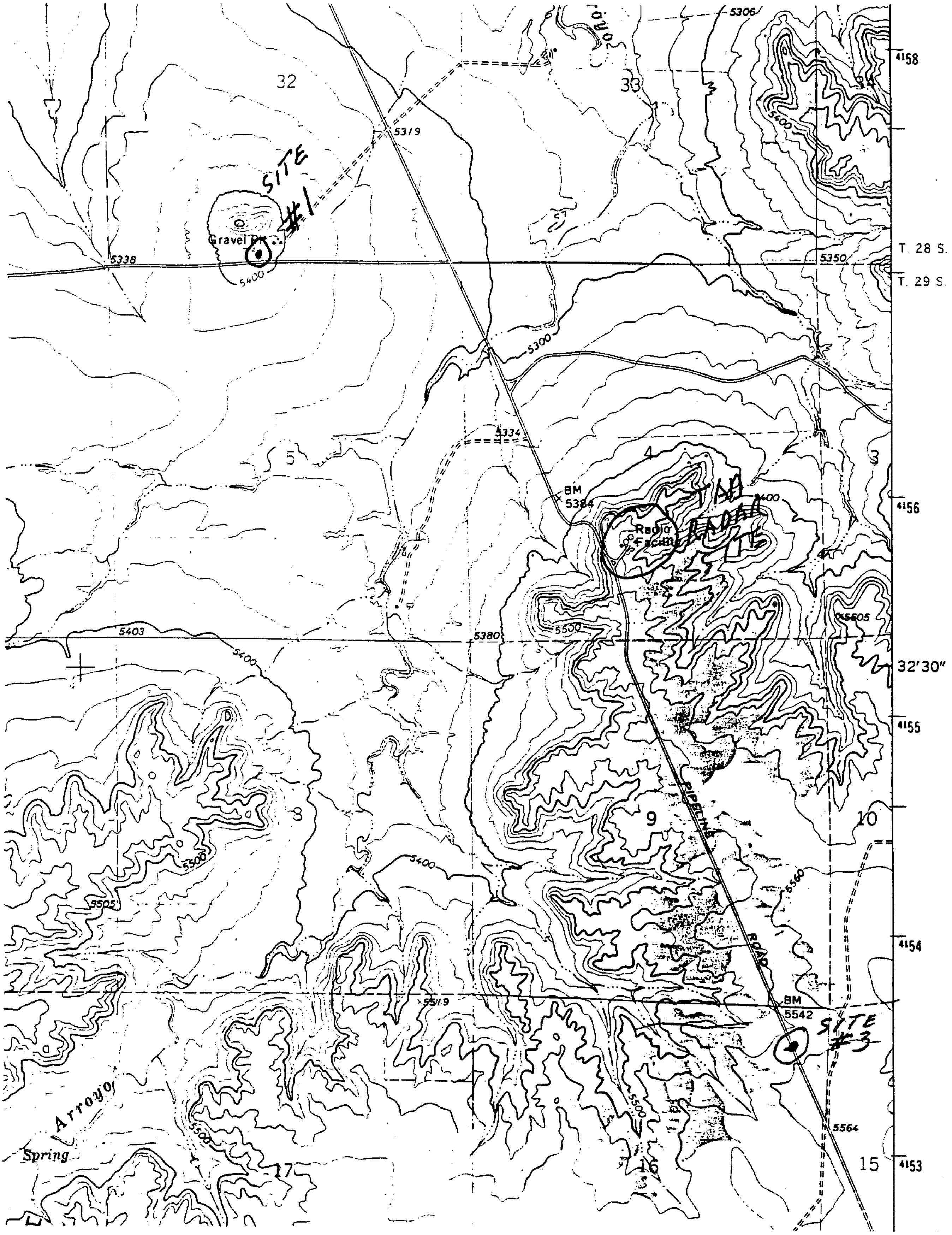
e. Common Digitizer Record (CDRECORD) - The CDRECORD program provides the capability to record on magnetic tape, CD data as received over the Data Receiver Group (DRG)/HOST computer system interface. The CDRECORD program is run on the HOST computer system.

f. PLOTCD - The PLOTCD program provides the capability to plot and sort aircraft and weather data in a polar presentation on a International Business Machines Corporation (IBM) compatible personal computer (PC) graphics display. The target data is retrieved from a CDRECORD disk file. The PLOTCD program is run on the Transportable Radar Analysis Computer System (TRACS) PC.

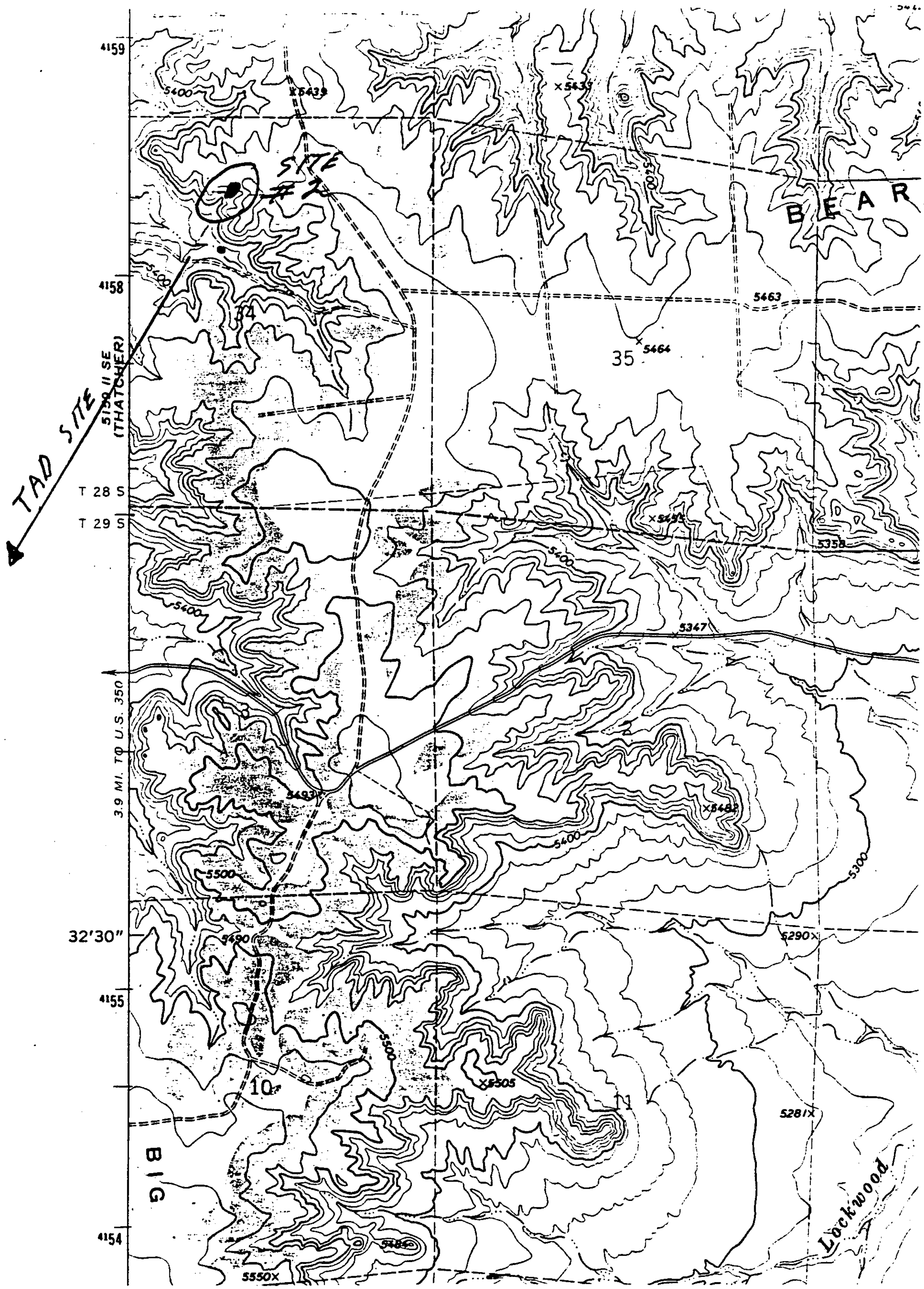
APPENDIX C

RFIM VAN LOCATIONS

TRINIDAD EN ROUTE RADAR FACILITY (TAD)



Thatcher Quadrangle, Las Animas County, Colorado - 1970
7.5 Minute (Topographic)
Scale 1:24,000, Contour Interval 20 Feet



Lockwood Arroyo Quadrangle, Las Animas County, Colorado - 1984
7.5 Minute (Topographic)
Scale 1:24,000, Contour Interval 20 Feet

APPENDIX D

QARS DATA

ALBUQUERQUE (ZAB) AND DENVER (ZDV) ARTCC

Albuquerque QARS Data for Trinidad, CO

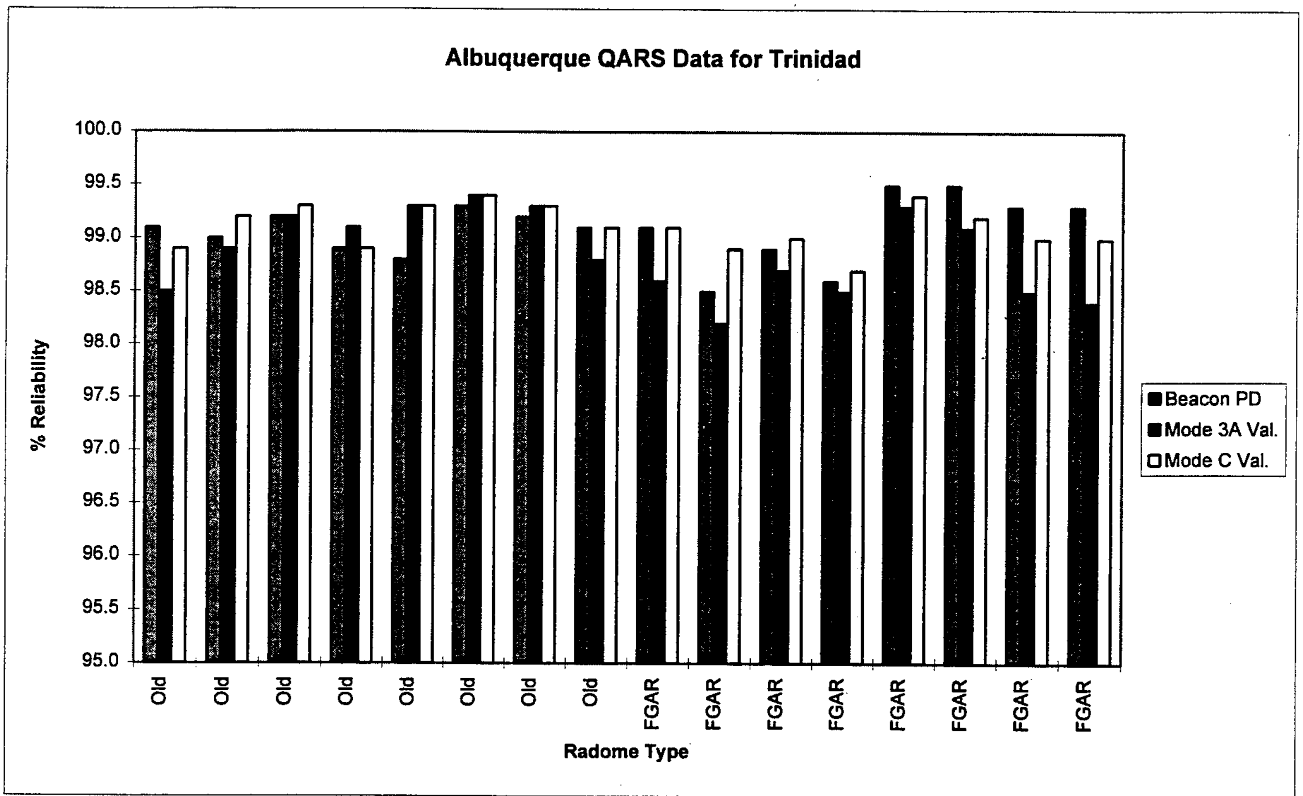
Radome Type		Old	Old	Old	Old	Old	Old	Old	Old	FGAR	FGAR	FGAR	FGAR	FGAR	FGAR	FGAR	FGAR
Date	Fail Criteria	10/7/94	10/8/94	10/9/94	10/10/94	10/11/94	10/12/94	10/13/94	10/14/94	11/3/94	11/4/94	11/5/94	11/6/94	11/7/94	11/8/94	11/12/94	11/13/94
BEACON																	
Scans		28437	25765	31688	31166	30481	30331	31478	29862	17892	19224	20544	26139	18524	20274	17699	21562
Blip/Scan	<96%	99.1	99.0	99.2	98.9	98.8	99.3	99.2	99.1	99.1	98.5	98.9	98.6	99.5	99.5	99.3	99.3
Search/Reinforced	<85/60/50%	80.4	32.8	60.0	60.5	76.2	61.9	76.6	80.0	79.7	79.4	70.3	78.7	79.9	80.6	68.5	66.3
Total Coll %	<98/85/70%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Az.Split	>.1/.2/.2%	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rng.Split	>.1/.2/.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Ring-Around	>.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Reflections	>.2%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Code 0000s	>.5%	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Mode 3/A Rel.	<98%	99.0	99.4	99.6	99.5	99.6	99.7	99.6	99.3	99.2	98.9	99.2	99.2	99.6	99.6	99.0	98.9
Mode 3/A Val.	<98%	98.5	98.9	99.2	99.1	99.3	99.4	99.3	98.8	98.6	98.2	98.7	98.5	99.3	99.1	98.5	98.4
Mode C Rel.	<98/97%	99.5	99.6	99.6	99.5	99.7	99.7	99.7	99.6	99.6	99.5	99.5	99.3	99.7	99.7	99.5	99.4
Mode C Val.	<97/95%	98.9	99.2	99.3	98.9	99.3	99.4	99.3	99.1	99.1	98.9	99.0	98.7	99.4	99.2	99.0	99.0
Mode C Scans		28118	25433	31414	30761	30042	30100	31149	29552	17709	18846	20282	24720	18427	20163	17537	21359
Rng. Dev.	>0/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Az.Dev.	>2.0	1.6	1.6	1.68	1.65	1.75	1.6	1.65	1.62	1.58	1.62	1.6	1.6	1.56	1.65	1.58	1.55
LOG/NML																	
Scans		18798	15877	19874	20596	20593	20629	21302	20053	11578	13685	12528	15462	11639	13851	12243	13348
Blip/Scan	<85/75/75%	81.0	34.0	60.8	61.0	77.6	61.8	78.6	78.6	79.6	79.5	69.2	82.1	81.5	79.8	68.5	68.0
Coll %	<96/85/70%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Az.Splits	>.2%	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rng.Splits	>3/3/6%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MTI																	
Scans		9639	9888	11814	10570	9888	9702	10176	9809	6314	5539	8016	9677	6885	6423	5456	8214
Blip/Scan	<85/70/65%	78.1	30.2	57.9	58.1	71.7	61.2	71.2	82.0	79.1	78.1	70.9	71.7	76.5	81.8	67.7	62.9
Coll %	<98/85/70%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Az.Splits	>.2%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rng.Splits	>3/3/6%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PE VERIFICATION																	
#1 Rng. Error	>0/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
#1 Az.Error	>2.0	1.0	0.8	0.6	0.6	0.5	0.6	-3.1	1.0	0.4	0.4	0.6	0.5	0.6	0.3	0.5	0.6
#1 % Rel.	<90%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TOTAL TRACKS		260	225	274	270	266	253	353	253	128	148	163	178	139	143	133	163
SCH/BCN CHANNELS		B/B	B/B	B/A	B/A	B/A	B/A	B/A	B/B	A/B	A/B	A/B	A/B	A/A	B/A	B/B	B/B

FIGURE D-1 ALBUQUERQUE ARTCC (ZAB) QARS DATA

Denver QARS Data for Trinidad, CO

Radome Type		Old	Old	Open	FGAR	FGAR	FGAR	FGAR	FGAR	FGAR	FGAR
Date	**Fail Criteria**	10/3/94	10/5/94	10/26/94	11/3/94	11/4/94	11/5/94	11/6/94	11/7/94	11/9/94	11/10/94
BEACON											
Scans		34815	27533	19876	30935	27268	27634	23990	25720	25242	22074
Blip/Scan	<96%	99.4	99.4	98.8	99.2	99.3	98.1	98.7	99.3	99.7	98.4
Search/Reinforced	<85/60/50%	79.9	82.4	32.2	82.0	80.5	68.9	80.3	78.6	83.0	65.7
Total Coll %	<98/85/70%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Az.Split	>.1/.2/.2%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rng.Split	>.1/.2/.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ring-Around	>.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Reflections	>.2%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Code 0000s	>.5%	0.1	0.3	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.1
Mode 3/A Rel.	<98%	99.4	98.8	99.2	98.9	98.9	99.0	98.8	99.3	99.7	98.9
Mode 3/A Val.	<98%	98.9	98.0	98.5	98.1	98.2	98.3	98.0	98.9	99.5	98.1
Mode C Val.	<98/97%	99.6	99.2	99.4	99.4	99.4	99.4	99.2	99.5	99.8	99.4
Mode C Rel.	<97/95%	99.2	98.4	98.7	98.6	98.7	98.9	98.4	98.0	99.5	98.9
Mode C Scans		34561	27338	19579	30662	27028	26971	23602	25517	25161	21634
Rng. Dev.	>0/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Az.Dev.	>2.0	1.67	1.69	1.61	1.7	1.73	1.65	1.67	1.64	1.66	1.52
LOG/NML											
Scans		23393	19119	13341	21407	18908	18573	15981	16817	18117	12932
Blip/Scan	<85/75/75%	79.0	81.8	32.9	82.8	81.5	69.5	83.8	81.2	82.7	66.5
Coll %	<96/85/70%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Az.Splits	>.2%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Rng.Splits	>3/3/6%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MTI											
Scans		11422	8414	6535	9528	8360	9061	8009	8903	7125	9142
Blip/Scan	<85/70/65%	81.2	83.4	29.8	79.2	77.2	64.7	71.6	73.1	83.2	62.9
Coll %	<98/85/70%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Az.Splits	>.2%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rng.Splits	>3/3/6%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PE VERIFICATION											
#1 Rng. Error	>0/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
#1 Az.Error	>2.0	1.0	1.0	1.3	0.4	0.2	0.4	0.5	0.3	0.3	0.6
#1 % Rel.	<90%	100.0	100.0	98.0	100.0	100.0	100.0	96.0	100.0	100.0	100.0
TOTAL TRACKS		244	209	183	202	194	217	214	192	197	178
SCH/BCN CHANNELS		B/B	B/B	A/A	A/B	A/B	A/B	A/B	A/A	B/A	B/B

FIGURE D-2 DENVER ARTCC (ZDV) QARS DATA



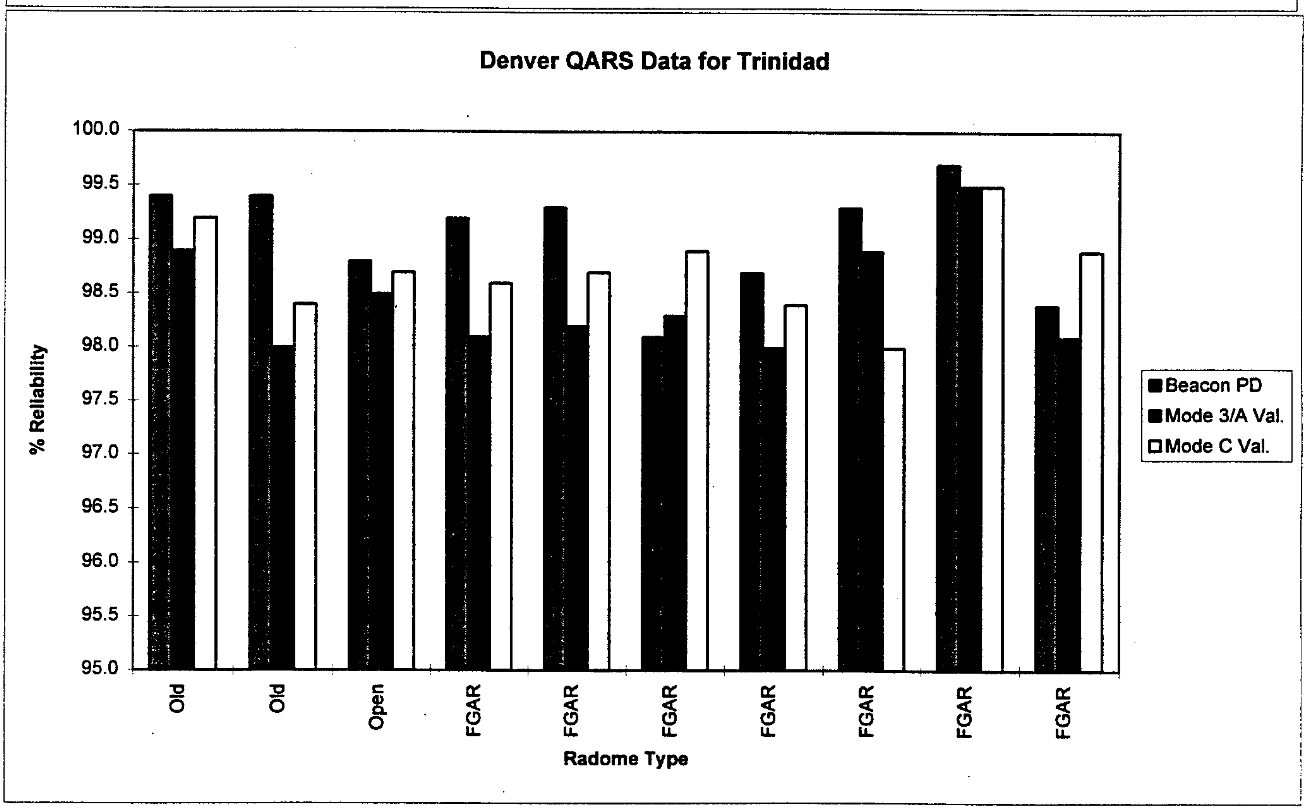


FIGURE D-3 QARS DATA GRAPHS

APPENDIX E

ATCS QUESTIONNAIRE RESPONSES

ALBUQUERQUE ARTCC (ZAB)

ATCS EVALUATION QUESTIONS	YES	NO	Number Not Responding	Percentage Of Favorable Responses
PART I - PRIMARY (ARSR) RADAR EVALUATION				
1. Has the detection of primary targets changed, i.e., more or less: target drops, detection at various altitudes, less detection as target range increases?	9	21	0	70.0
2. Has the displayed primary track trajectories changed, i.e., track histories: are they following a straight or arched path smoothly, or do they appear to be shifting back and forth in azimuth from scan to scan?	9	21	0	70.0
3. Has the number of primary false targets changed, i.e., false targets appearing more frequently or at undesirable locations?	10	20	0	66.7
4. Are the primary Permanent Echo's (PE) where they were before?	25	2	3	92.6

FIGURE E-1 ATCS QUESTIONNAIRE RESPONSES
ALBUQUERQUE ARTCC (ZAB)

	ATCS EVALUATION QUESTIONS	YES	NO	Number Not Responding	Percentage Of Favorable Responses
	PART II - SECONDARY (BEACON) RADAR EVALUATION				
1.	Has the detection of beacon targets changed, i.e., more or less: target drops, detection at various altitudes, less detection as target range increases?	12	17	1	58.6
2.	Has the displayed beacon track trajectories changed, i.e., track histories: are they following a straight or arched path smoothly, or do they appear to be shifting back and forth in azimuth from scan to scan?	8	21	1	72.4
3.	Has the number of beacon false targets changed, i.e., target splits, code swaps, incorrect code changes, false targets appearing more frequently, or at undesirable locations?	9	20	1	70.0
4.	Are you experiencing any beacon target ring-around not seen before?	7	23	0	76.7
5.	Are the beacon Permanent Echo's (PE) where they were before?	23	4	3	85.2
6.	Does the radar to beacon reinforcement appear the same?	24	3	3	88.9

FIGURE E-1 ATCS QUESTIONNAIRE RESPONSES
ALBUQUERQUE ARTCC (ZAB) [Continued]

ATCS EVALUATION QUESTIONS	YES	NO	Number Not Responding	Percentage Of Favorable Responses
PART III - OVERALL EVALUATION				
1. Do you detect any degradation in the data displayed not experienced before?	11	18	1	62.1
2. Since the new radome has been installed, taking into account the limited time you have had in performing your air traffic control duties with the new radome, do you see or know of any reason why the FAA should not continue the replacement of en route radomes?	6	20	4	76.9

FIGURE E-1 ATCS QUESTIONNAIRE RESPONSES
ALBUQUERQUE ARTCC (ZAB) [Continued]

APPENDIX F

REPORT

MODE S TESTING

TECHNICAL CENTER'S ELWOOD ERBTF

U.S. Department
of Transportation
Federal Aviation Administration

Memorandum

Subject: REPORT - FGAR Mode S OT&E Testing at the Technical Center's Elwood ERBTF

Date: Jan 31, 1995

From: Andrew Leone, Mode S Engineer, ACW-100B

Reply to Attn of:

To: Associate Program Manager for Test (APMT), ACW-100B

1. INTRODUCTION.

Operational Test and Evaluation (OT&E) testing of the Fixed Ground Antenna Radome (FGAR) was performed at the FAA Technical Center's Elwood En Route Beacon Test Facility (ERBTF), during the period August 15 to December 6, 1994. The testing was performed using the Mode Select (Mode S) Beacon System in a beacon only configuration, since the Mode S-to-Common Digitizer (CD) -2 interface was not available. The Mode S software version used during the testing was a TR21.4 image modified to support the en route coverage map and dissemination format. In addition, CD-2 data were collected with the AN/UPX-27 beacon system and the Mode S operating in the Interim Beacon Initiative (IBI) configuration, with the Air Route Surveillance Radar (ARSR) -2.

Mode S data extraction data were analyzed using the Mode S Data Reduction (DR) program. The CD-2 format data were analyzed with the Radar Beacon Analysis Tool (RBAT) program.

A performance baseline was established with the Mode S by conducting a series of data collection runs with the inflatable radome, as well as two days without a radome installed. The analysis focused on (1) surveillance performance, (2) monopulse accuracy, (3) false target detection, (4) nine point track performance, and (5) fruit detection. These data verified proper system operation and provided a baseline to which the FGAR data could be compared.

2. TEST DESCRIPTIONS AND RESULTS.

The data collection runs were a minimum of 200 scans long and were usually performed in the morning between 0700 and 0900 local time. The last day of FGAR data collection followed two days of rain, and is labeled "FGAR Wet" on the figures and tables.

Mode S data collection via the Mode S Recording Display Equipment (MARDE), consisted of recording all: (1) interrogations, (2) target replies and reports, (3) surveillance track file data, and (4) dissemination data. In addition, CD-2 format dissemination data were collected at the Mode S modem ports using the Real-Time Analysis Display System (RTADS).

CD-2 output data were collected, at the RTADS, using the ARSR-2 together with either the Mode S operating in the IBI configuration or the AN/UPX-27 beacon system, as radar input. Due to problems in the ARSR-2 and CD-2, the data collected were marginal at best. However, the range and azimuth accuracy, when all systems where operating nominally, showed equivalent values with the inflatable radome and the FGAR.

Though data were collected with no radome installed, the analysis showed significantly larger errors, especially those relating to nine point azimuth accuracy. These errors can only be attributed to wind loading on the antennas. Due to the larger errors, these data have not been included in this report.

The following are the results and a discussion of the data analysis programs.

a. Beacon False Target Summary.

A comparison of the overall false target percentages demonstrated that the FGAR did not increase false target detection. The false target average decreased 0.15% after the FGAR was installed. Splits, uplink and downlink reflections, pulse repetition frequency (PRF), and ring-around percentages were all within nominal tolerances specified in Chapter 3, Standards and Tolerances, Order 6365.3, Maintenance of the Mode Select (Mode S) Beacon System.

Table 1 shows the summary data for the data collection runs. Figures 1 and 2 provide a graph of the false target and target split percentages, respectively. Each point on the X-axis represents a data collection run with a minimum of 200 scans of data.

b. Monopulse Analysis.

Monopulse accuracy was measured using the Mode S Calibration Performance Monitor Equipment (CPME). There was no degradation in azimuth accuracy across the beam with the FGAR detected. The Mode S maintained azimuth accuracy within ±0.033° (1.5 AU), as required by specification FAA-E-2716, Mode Select (Mode S) Beacon

System Sensor, with both the inflatable radome and the FGAR.

Figure 3 is a plot of the mean and standard deviation of the monopulse reply values versus the CPME's boresight azimuth. Figure 4 is a plot of the mean and standard deviation of the azimuth error versus the CPME's boresight azimuth. Figure 5 is a plot of absolute azimuth error versus the CPME's boresight azimuth. These plots were made with the inflatable radome installed. Figures 6 through 8 are similar plots with the FGAR installed.

c. Nine Point Analysis.

Summary totals for the nine point analysis program, using Mode S data extraction, was done as a broad gauge of overall tracking accuracy. The numbers used for comparison were the mean average of the standard deviation of error for all tracks within a given data collection run. Though the figures may appear to show poor overall tracking accuracy with respect to FAA-E-2716 requirements, particularly range errors, they are in fact biased due to a number of individual tracks. These tracks are either flying towards or away from the site, skirting the fringes of the beam, or performing turns, e.g., approaching or departing terminal sites. Therefore, these numbers can only be used for limited comparison. In general, range error decreased by 4.9%. However, azimuth errors increased by 1.5%, but were still within the 0.068° root-mean-square (RMS) accuracy required by specification FAA-E-2716.

Table 2 and figures 9 and 10 show the summary range and azimuth errors, for both Mode S and Air Traffic Control Radar Beacon System (ATCRBS) targets, for all of the data collection runs.

To eliminate fringe targets, a comparison was done at the dissemination level using the RBAT analysis package to filter the targets so that analysis could be performed on data within the main antenna beam coverage area. This area was defined as being within a range of 5 to 200 nautical miles (NM), 0 to 360°, between 5,000 and 50,000 feet, and with an elevation angle of 0.5° to 35°. This was done with the following sets of data: (1) Mode S, (2) CD-2 with Mode S operating in the IBI configuration, and (3) CD-2 with AN/UPX-27 beacon system data. The range and azimuth errors are greater than those derived from the Mode S data extract analysis, this is due to the coarser range and azimuth resolution within the message formats.

The FGAR improved the range error performance by the following:

1) Mode S - 0.3%

2) CD-2 with Mode S operating in the IBI configuration -1.1%

3) CD-2 with AN/UPX-27 beacon system - 1.1%

The azimuth error performance, with the FGAR installed, was varied:

1) Mode S - degraded 7.8%

2) CD-2 with Mode S operating in the IBI configuration - improved 7.8%

3) CD-2 with AN/UPX-27 beacon system - degraded 9.1%

Table 3 and figures 11 and 12 show the summary range and azimuth errors for all targets during the data collection runs.

To more accurately determine nine point accuracy, a select number of targets were analyzed. These targets were a mix of Mode S and ATCRBS tracks with a radial or tangential flight path. They were targets of high detection, code reliability, and code confidence. The data were filtered to eliminate targets ascending, descending, approaching or departing the antenna beam coverage area, and to eliminate any targets maneuvering within terminal areas. The results demonstrated an equivalent level of performance between the inflatable radome and FGAR. Tables 4 through 7 and figures 13 through 20 show the range and azimuth standard deviations for each selected target. The average errors of the selected tracks showed a slight decrease in the range error of 3.5%, with the FGAR installed. The azimuth error showed a degradation of 49%. Though the azimuth errors increased significantly with respect to the inflatable radome, the average azimuth error was still within the limits specified by FAA-E-2716. Figures 21 and 22 are a plot of a selected Mode S and an ATCRBS track for the inflatable radome (Note: range rings are in 10 NM increments). Figures 23 and 24 are a plot of similar tracks for the FGAR. These plots provide a visual representation of the tracks as would be displayed on a Air Traffic Control Specialist (ATCS) display. They indicate there was no additional stitching of the tracks.

d. Surveillance Analysis.

The Mode S and ATCRBS overall probability of detection (PD), identification (ID) reliability and confidence, and the altitude reliability and confidence were acceptable. The FGAR did not significantly degrade performance in any category. The average:

1) PD increased 0.06%

2) ID reliability decreased 0.14%

3) ID confidence decreased 0.17%

4) Altitude reliability increased 0.31%

5) Altitude confidence increased 0.44%

Figure 25 shows the overall PD for each data collection run. Tables 8 through 10 and figures 26 through 33 show the overall PD, code reliability and confidence, and altitude reliability and confidence for Mode S and ATCRBS targets.

e. Fruit Analysis.

The average levels of Mode S and ATCRBS fruit decreased after the FGAR was installed. Mode S fruit decreased approximately 22% and ATCRBS fruit decreased approximately 5%. Table 11 and Figure 34 show the fruit levels detected for each data collection run.

3. CONCLUSIONS.

The Mode S surveillance performance tests indicated the quality and accuracy of the data provided by the Mode S with the FGAR installed has not been significantly improved or degraded, when compared to the inflatable radome.

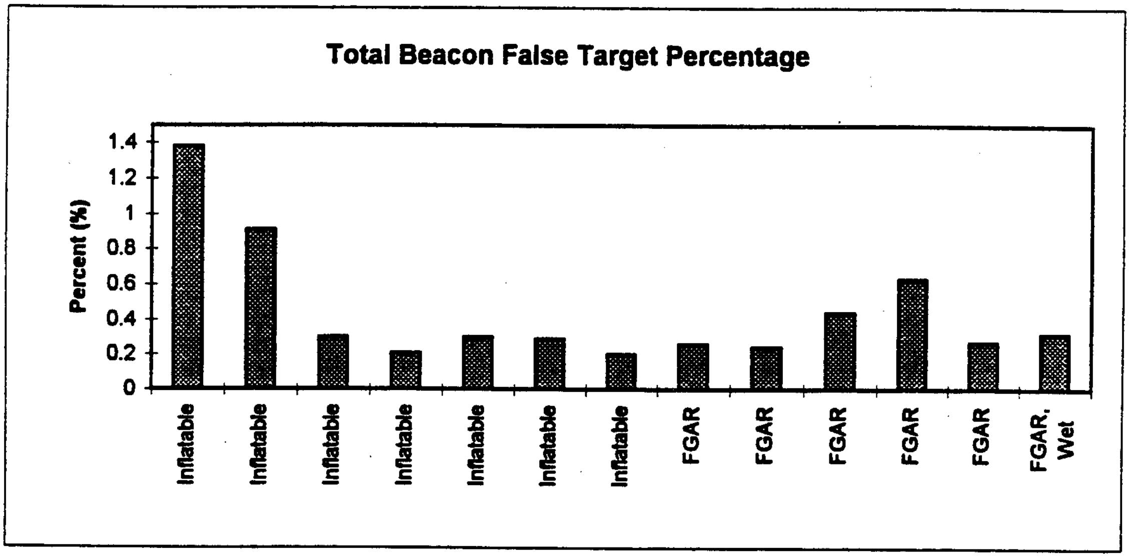
If you have any questions, contact Andrew Leone, at (609) 485-5578.

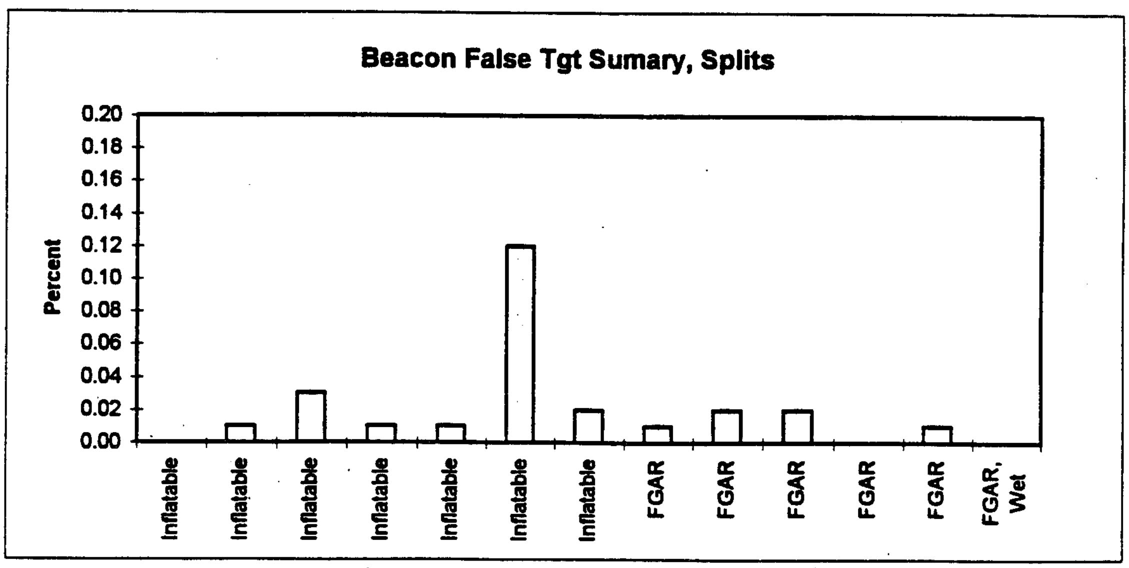
Andrew Leone
Mode S Engineer, ACW-100B

Enclosures

TABLE 1

		Total False Tgts	Total Tgt Rpts	False Tgt %	Split		Ringaround		Down Refl.		PRF		Up Refl.		Other	
					No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
		Nominal Limits →				<0.2		<1.0		<1.0		<1.0		<1.0		
Inflatable	9/12/94	841	60839	1.38	2	0.00	0	0.00	0	0.00	0	0.00	6	0.01	502	0.70
Inflatable	9/13/94	624	68949	0.91	10	0.01	0	0.00	1	0.00	3	0.00	0	0.00	405	0.00
Inflatable	9/14/94	195	65210	0.3	19	0.03	0	0.00	1	0.00	2	0.00	0	0.00	140	0.20
Inflatable	9/15/94	109	51996	0.21	6	0.01	0	0.00	0	0.00	0	0.00	0	0.00	5	0.01
Inflatable	9/16/94	174	58588	0.3	8	0.01	0	0.00	0	0.00	1	0.00	2	0.00	120	0.20
Inflatable	9/19/94	172	58924	0.29	78	0.12	0	0.00	0	0.00	1	0.00	0	0.00	7	0.01
Inflatable	9/20/94	114	56038	0.2	11	0.02	0	0.00	0	0.00	0	0.00	0	0.00	13	0.02
FGAR	10/17/94	196	76512	0.26	10	0.01	0	0.00	0	0.00	0	0.00	2	0.00	94	0.11
FGAR	10/18/94	131	55718	0.24	13	0.02	1	0.00	0	0.00	4	0.01	2	0.00	14	0.02
FGAR	10/19/94	317	71705	0.44	20	0.02	0	0.00	1	0.00	24	0.03	4	0.00	126	0.16
FGAR	10/20/94	290	46328	0.63	2	0.00	0	0.00	0	0.00	4	0.01	0	0.00	277	0.56
FGAR	10/21/94	146	53163	0.27	6	0.01	1	0.00	1	0.00	0	0.00	0	0.00	79	0.14
FGAR. Wet	12/6/94	187	58914	0.32	1	0.00	0	0.00	3	0.00	0	0.00	0	0.00	105	0.16





FIGURES 1 & 2

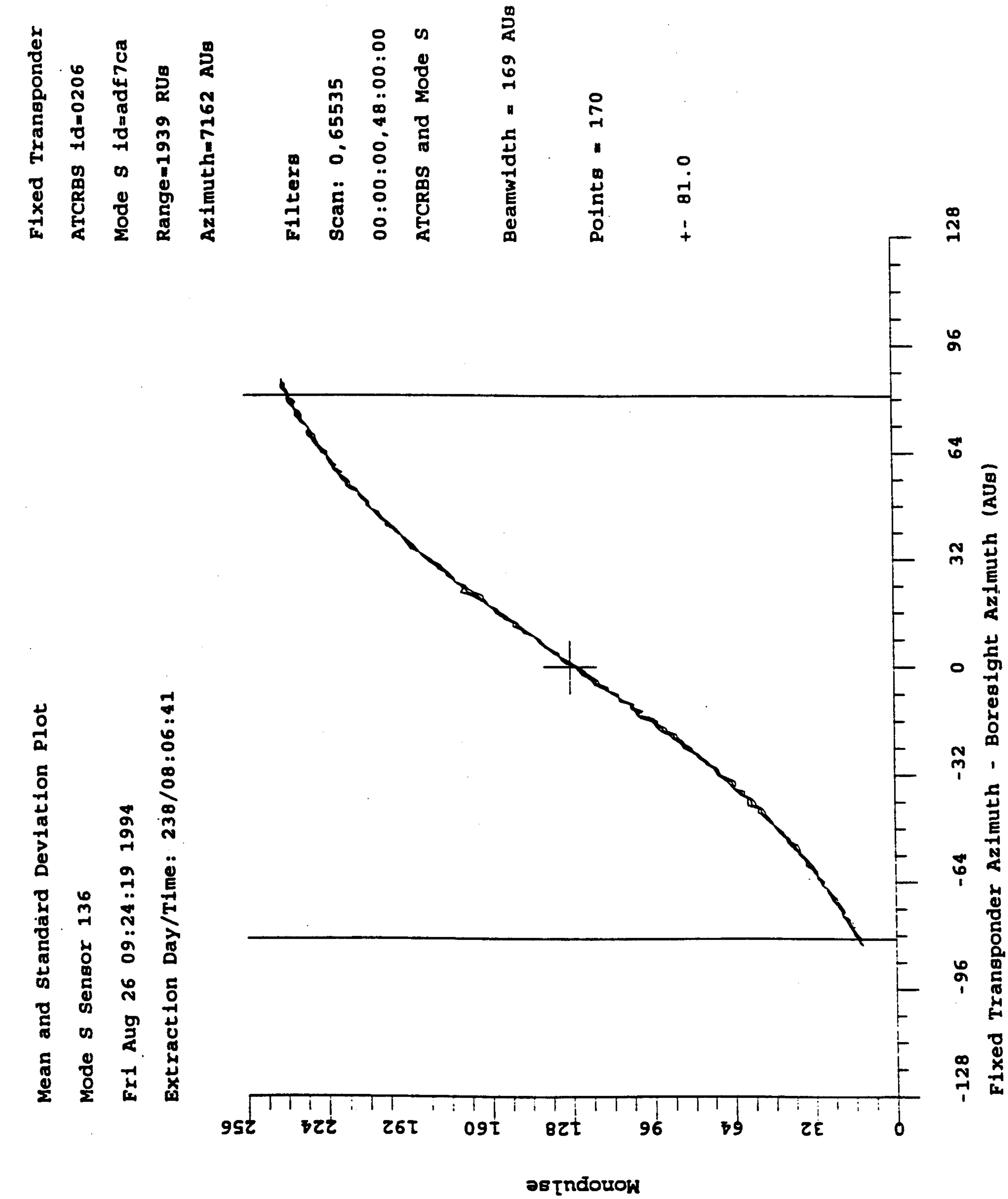

Mean and Standard Deviation Plot
Mode S Sensor 136
Fri Aug 26 09:24:19 1994
Extraction Day/Time: 238/08:06:41
Fixed Transponder
ATCRBS id=0206
Mode S id=adf7ca
Range=1939 RUs
Azimuth=7162 AUs
Filters
Scan: 0,65535
00:00:00,48:00:00
ATCRBS and Mode S
Beamwidth = 169 AUs
Points = 170
+- 81.0
Monopulse
0
32
64
96
128
160
192
224
256
-128
-96
-64
-32
0
32
64
96
128
Fixed Transponder Azimuth - Boresight Azimuth (AUs)

FIGURE 3

Mean and Standard Deviation Plot

Mode S Sensor 136

Fri Aug 26 09:24:19 1994

Extraction Day/Time: 238/08:06:41

Fixed Transponder

ATCRBS id=0206

Mode S id=adf7ca

Range=1939 RUs

Azimuth=7162 AUs

Filters

Scan: 0,65535

00:00:00,48:00:00

ATCRBS and Mode S

Beamwidth = 169 AUs

Points = 170

+- 81.0

+- 2.5

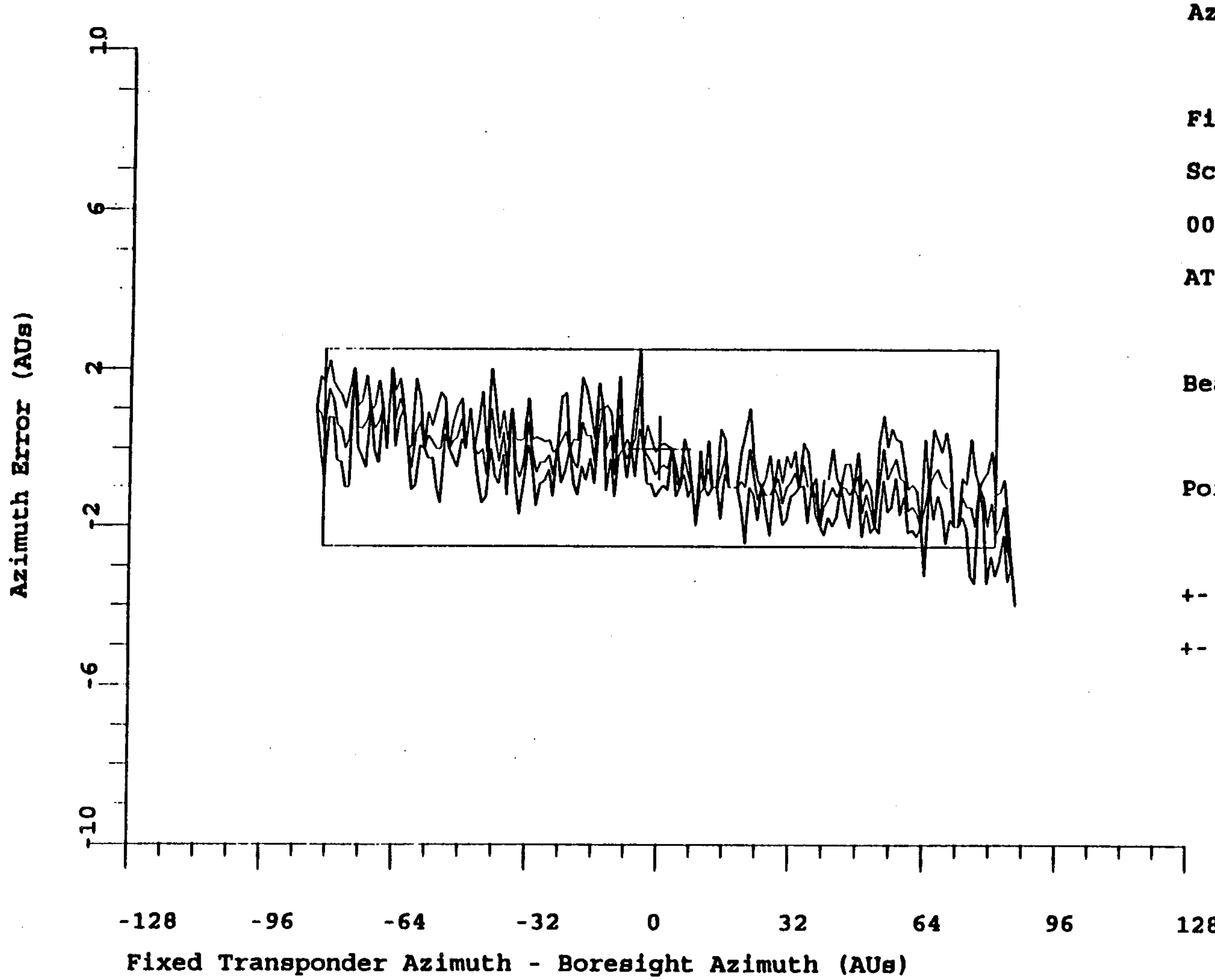


FIGURE 4

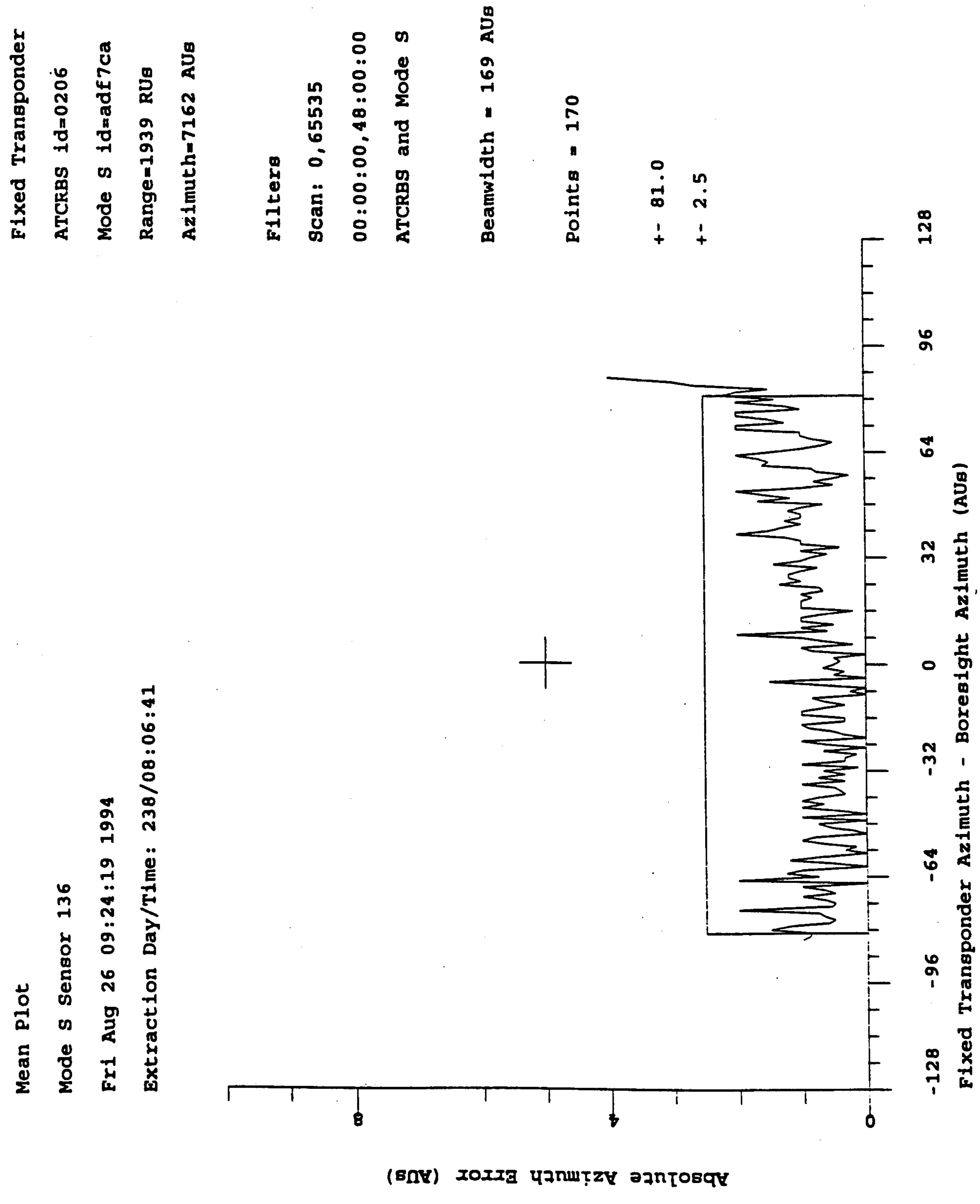

Mean Plot
Mode S Sensor 136
Fri Aug 26 09:24:19 1994
Extraction Day/Time: 238/08:06:41
Fixed Transponder
ATCRBS id=0206
Mode S id=adf7ca
Range=1939 RUs
Azimuth=7162 AUs
Filters
Scan: 0,65535
00:00:00,48:00:00
ATCRBS and Mode S
Beamwidth = 169 AUs
Points = 170
+- 81.0
+- 2.5
Absolute Azimuth Error (AUs)
0
4
8
-128
-96
-64
-32
0
32
64
96
128
Fixed Transponder Azimuth - Boresight Azimuth (AUs)

FIGURE 5

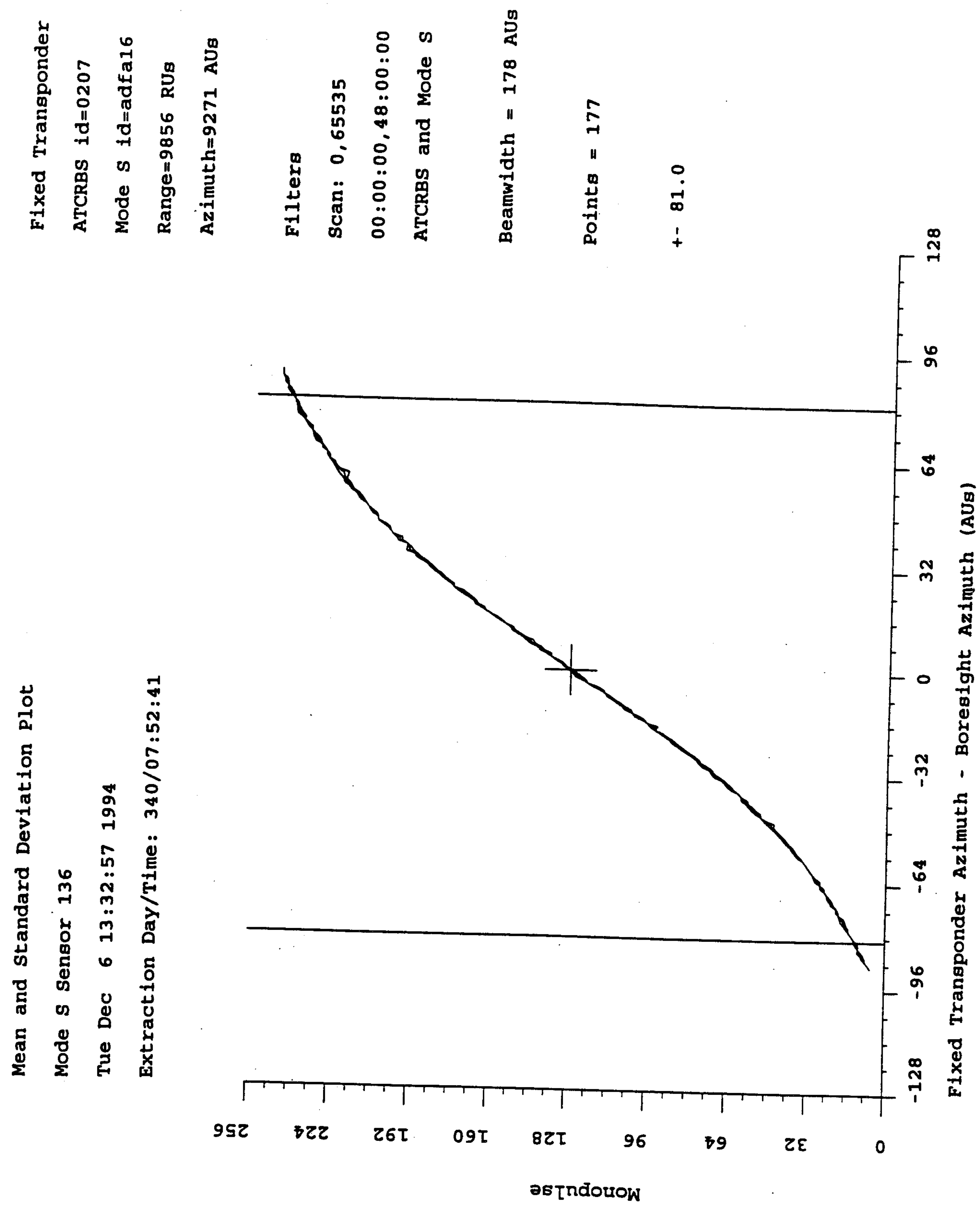

Mean and Standard Deviation Plot
Mode S Sensor 136
Tue Dec 6 13:32:57 1994
Extraction Day/Time: 340/07:52:41
Fixed Transponder
ATCRBS id=0207
Mode S id=adfa16
Range=9856 RUs
Azimuth=9271 AUs
Filters
Scan: 0,65535
00:00:00,48:00:00
ATCRBS and Mode S
Beamwidth = 178 AUs
Points = 177
+- 81.0
Monopulse
0
32
64
96
128
160
192
224
256
-128
-96
-64
-32
0
32
64
96
128
Fixed Transponder Azimuth - Boresight Azimuth (AUs)

FIGURE 6

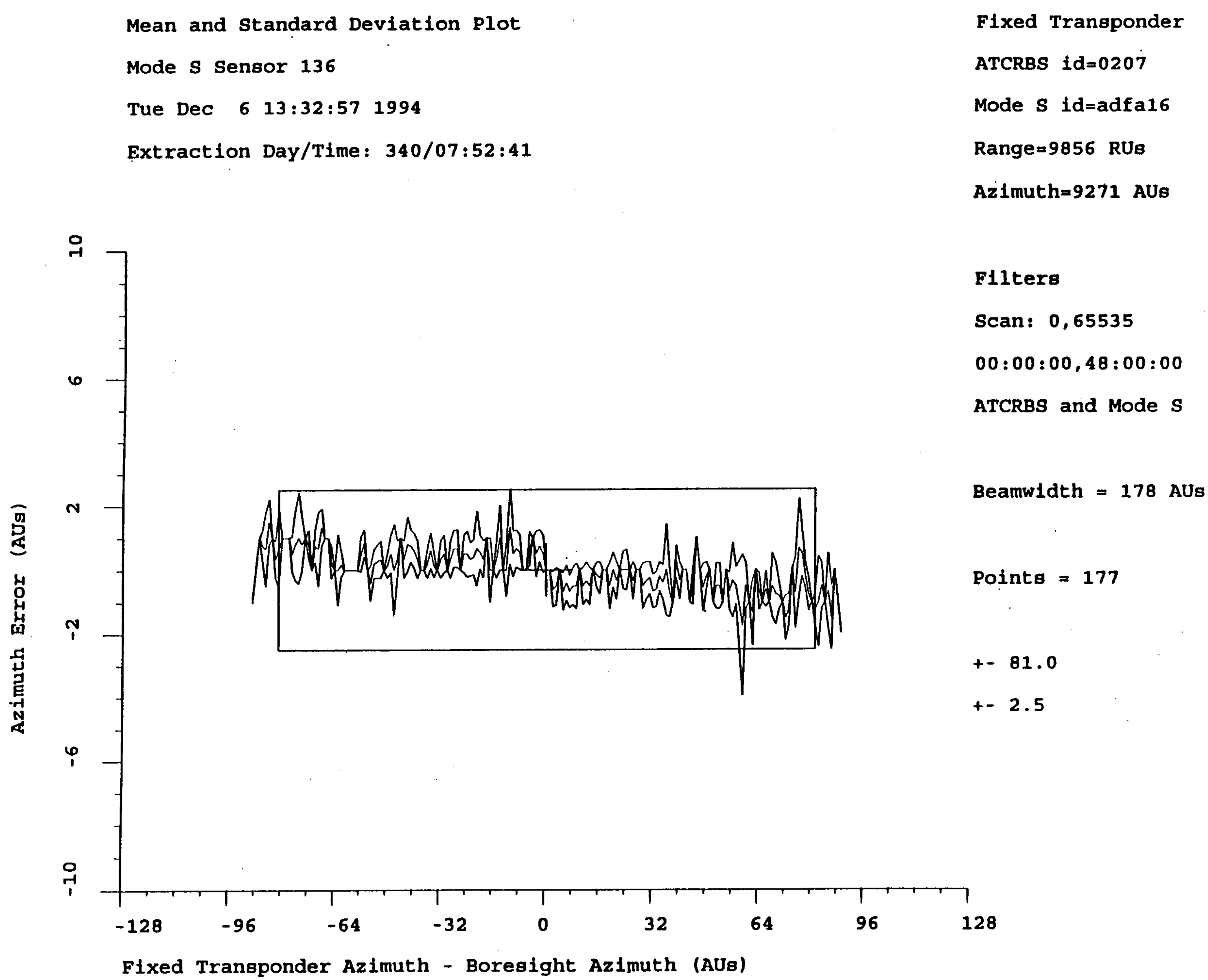

Mean and Standard Deviation Plot
Mode S Sensor 136
Tue Dec 6 13:32:57 1994
Extraction Day/Time: 340/07:52:41
Fixed Transponder
ATCRBS id=0207
Mode S id=adfa16
Range=9856 RUs
Azimuth=9271 AUs
Filters
Scan: 0,65535
00:00:00,48:00:00
ATCRBS and Mode S
Beamwidth = 178 AUs
Points = 177
+- 81.0
+- 2.5
Azimuth Error (AUs)
10
6
2
-2
-6
-10
-128
-96
-64
-32
0
32
64
96
128
Fixed Transponder Azimuth - Boresight Azimuth (AUs)

FIGURE 7

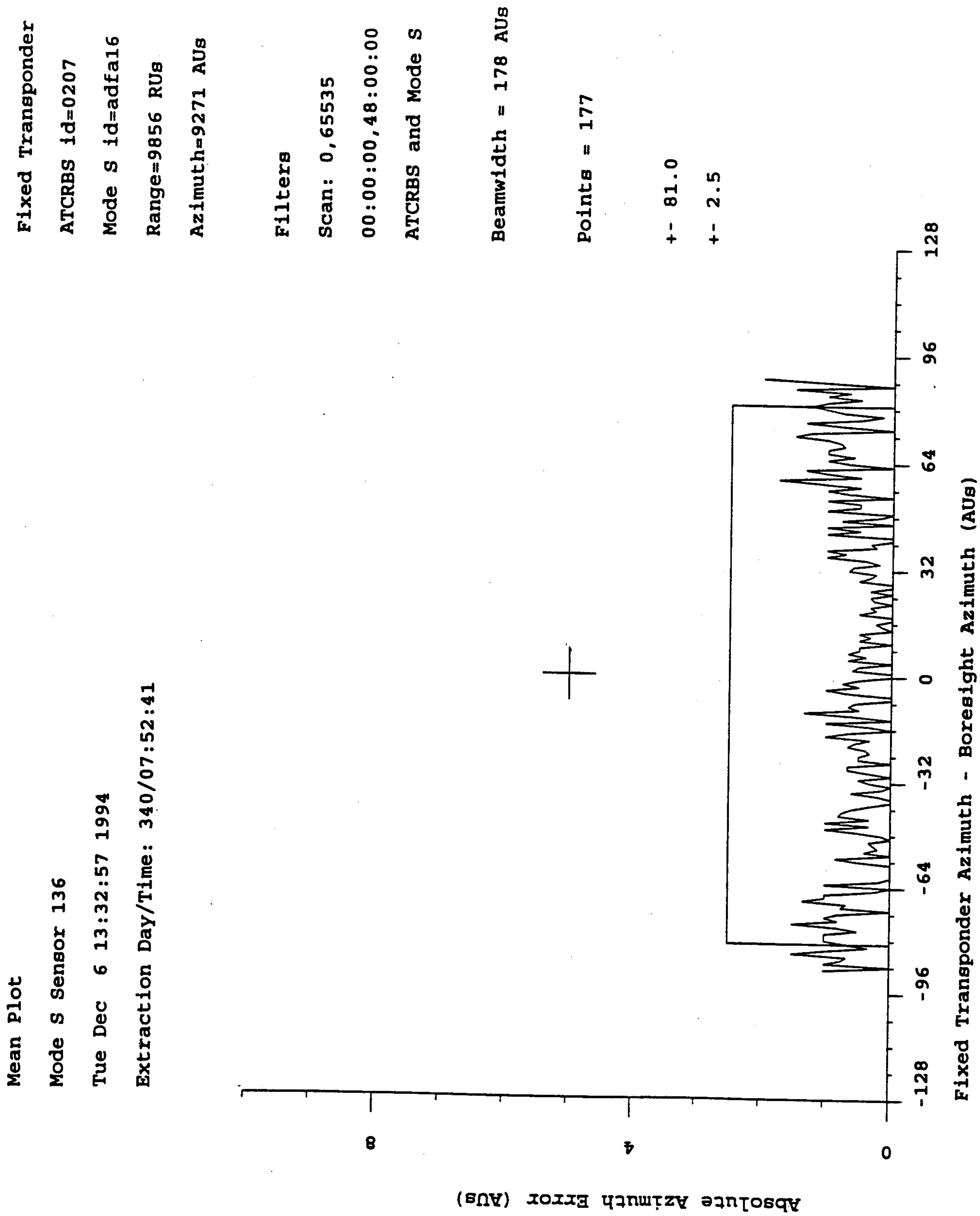
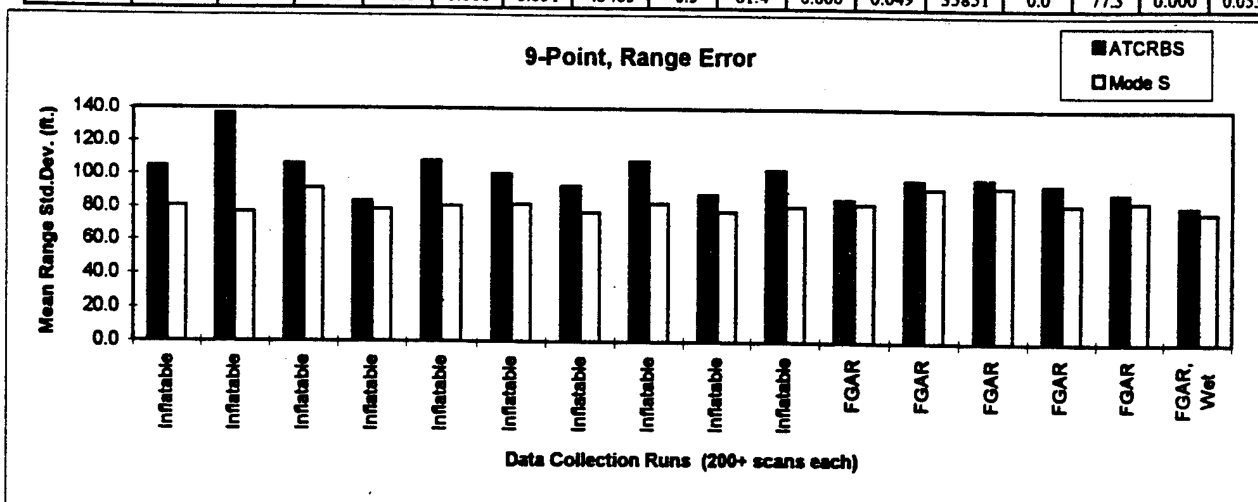
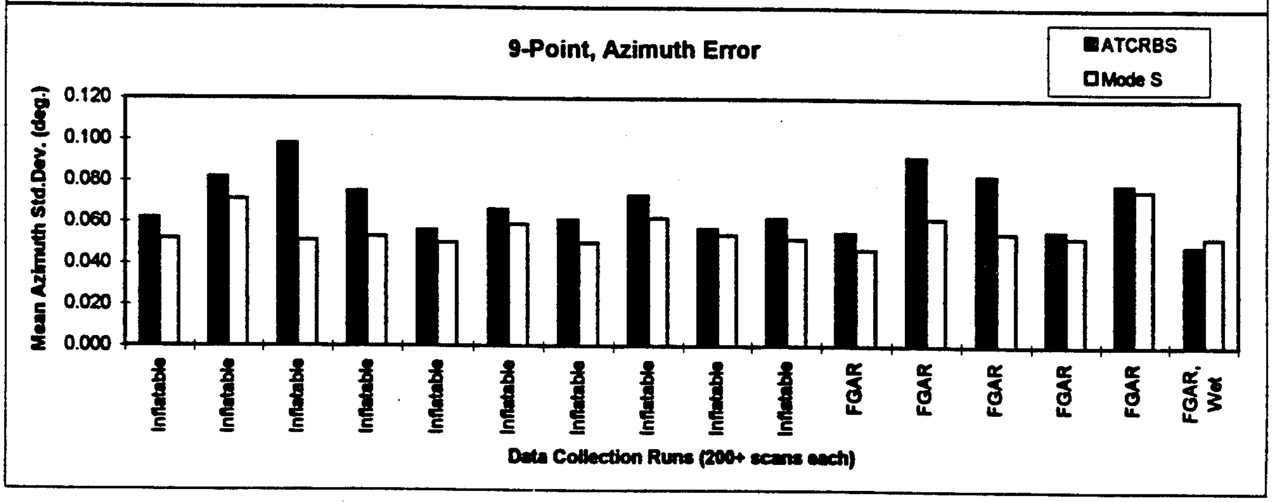

Mean Plot
Mode S Sensor 136
Tue Dec 6 13:32:57 1994
Extraction Day/Time: 340/07:52:41
Fixed Transponder
ATCRBS id=0207
Mode S id=adfa16
Range=9856 RUs
Azimuth=9271 AUs
Filters
Scan: 0,65535
00:00:00,48:00:00
ATCRBS and Mode S
Beamwidth = 178 AUs
Points = 177
+- 81.0
+- 2.5
Absolute Azimuth Error (AUs)
0
4
8
-128
-96
-64
-32
0
32
64
96
128
Fixed Transponder Azimuth - Boresight Azimuth (AUs)

FIGURE 8

TABLE 2

	Date	Total					ATCRBS					Mode S				
		Sample Size	Rg. Error (ft.)		Az. Error (deg.)		Sample Size	Rg. Error (ft.)		Az. Error (deg.)		Sample Size	Rg. Error (ft.)		Az. Error (deg.)	
			Mean	StdDev	Mean	StdDev		Mean	StdDev	Mean	StdDev		Mean	StdDev	Mean	StdDev
Inflatable	9/12/94	86390	0.0	93.1	0.000	0.057	42669	0.0	104.3	0.000	0.062	43721	0.0	80.6	0.000	0.052
Inflatable	9/13/94	90187	-0.2	111.6	0.000	0.076	46005	-0.5	137.0	0.000	0.082	44182	0.1	76.6	0.000	0.071
Inflatable	9/14/94	87565	-0.3	99.3	0.000	0.079	45706	-0.6	106.0	0.000	0.098	41859	-0.1	91.4	0.000	0.051
Inflatable	9/15/94	72758	-0.1	80.9	0.000	0.065	37158	-0.4	83.2	0.000	0.075	35600	0.0	78.4	0.000	0.053
Inflatable	9/16/94	80352	-0.2	95.8	0.000	0.053	41918	-0.3	107.8	0.000	0.056	38434	0.0	80.7	0.000	0.050
Inflatable	9/19/94	78756	0.0	90.8	0.000	0.062	37949	0.0	99.9	0.000	0.066	40807	-0.1	81.5	0.000	0.059
Inflatable	9/20/94	72467	-0.2	85.3	0.000	0.056	37296	-0.2	92.8	0.000	0.061	35171	-0.1	76.7	0.000	0.050
Inflatable	9/21/94	62675	-0.3	96.0	0.000	0.068	31726	-0.6	107.8	0.000	0.073	30949	0.0	82.3	0.000	0.062
Inflatable	9/22/94	62218	0.0	82.6	0.000	0.056	30159	0.0	87.9	0.000	0.057	32059	0.0	77.3	0.000	0.054
Inflatable	9/23/94	68796	0.0	91.3	0.000	0.057	31763	0.0	102.5	0.000	0.062	37033	0.0	80.4	0.000	0.052
FGAR	10/17/94	108250	0.0	83.7	0.000	0.052	54319	-0.2	84.9	0.000	0.055	53931	0.2	82.4	0.000	0.047
FGAR	10/18/94	70806	-0.1	94.2	0.000	0.078	35123	-0.1	96.7	0.000	0.092	35683	-0.1	91.7	0.000	0.062
FGAR	10/19/94	86894	-0.3	95.3	0.000	0.070	42773	-0.5	97.8	0.000	0.083	44121	-0.1	92.8	0.000	0.055
FGAR	10/20/94	65954	-0.3	89.1	0.000	0.055	36862	-0.4	94.1	0.000	0.056	29092	0.1	82.3	0.000	0.053
FGAR	10/21/94	80616	0.1	86.7	0.000	0.077	41225	0.0	89.3	0.000	0.079	39391	0.2	83.9	0.000	0.076
FGAR, Wet	12/6/94	79316	-0.3	79.6	0.000	0.051	43465	-0.5	81.4	0.000	0.049	35851	0.0	77.3	0.000	0.053





FIGURES 9 & 10

	Range Error (nm.)			Azimuth Error (deg.)		
	Mode S	IBI	UPX-27	Mode S	IBI	UPX-27
Inflatable	0.0440	0.0446	0.0440	0.0515	0.1697	0.1422
Inflatable	0.0438	0.0449	0.0451	0.0532	0.1481	0.1420
FGAR	0.0439	0.0438	0.0441	0.0619	0.1575	0.1577
FGAR	0.0436	0.0438	0.0440	0.0510	0.1354	0.1524

TABLE 3

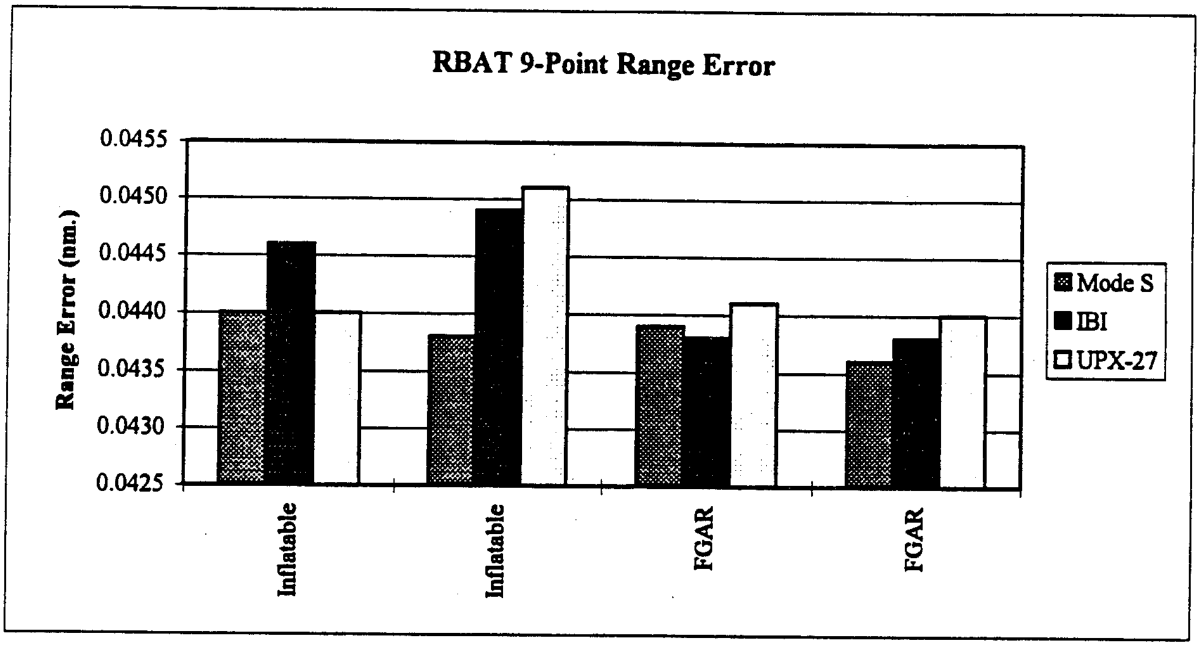


FIGURE 11

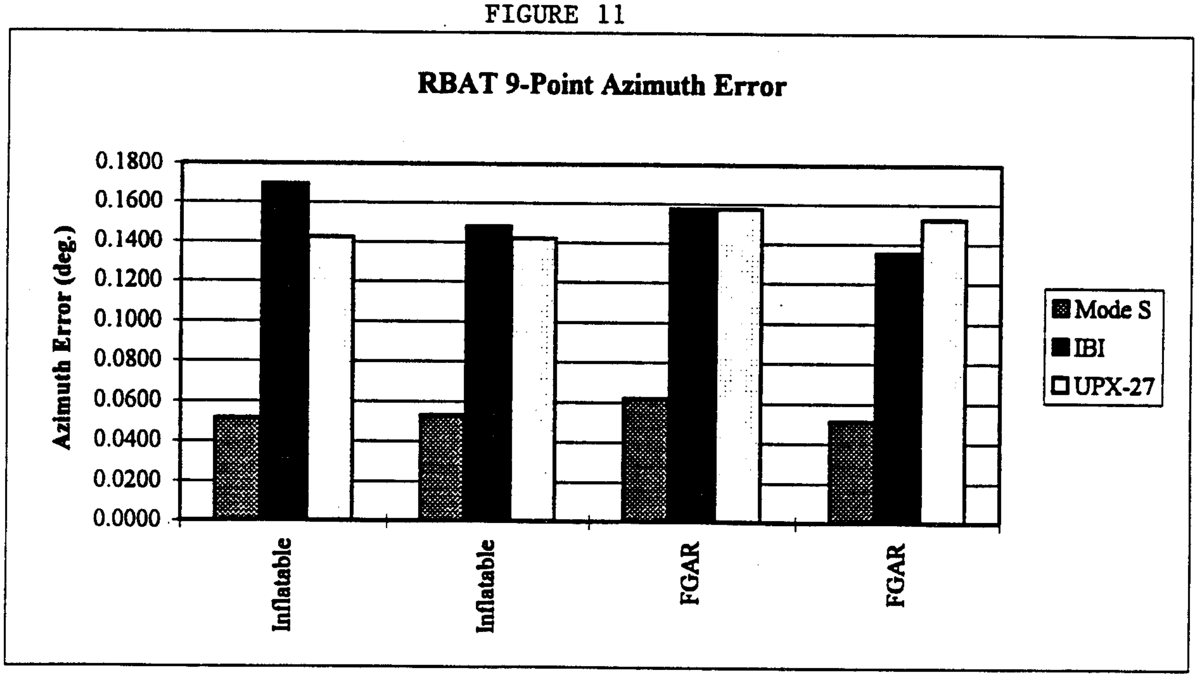


FIGURE 12

	Inflatable	Inflatable	Inflatable	Inflatable	Inflatable	FGAR	FGAR	FGAR	FGAR
Track No. (SFN)	423	194	104	555	242	9	264	256	63
Mode 3/A	3162	2015	3341	0522	0510	3073	1437	1624	7367
Mode S Id	a648df	a2867e	a828d1	acb86a	a0bf7c	a08a0e	aa7292	a07522	a00676
Mode S/ATCRBS (S/A)	S	S	S	S	S	S	S	S	S
Radial/Tangential (R/T)	T	T	T	T	T	T	T	T	T
Range (nmi)	176-54	102-87	81-175	120-67	54-84	107-200	145-76	81-200	140-121
Azimuth (deg.)	232-24	23-255	12-262	203-43	236-18	81-132	56-195	58-133	24-272
Altitude (100s ft.)	370-69	350-24	130-390	370-21	240-35	209-330	350-350	143-354	245-100
Scans	206	120	207	194	194	114	168	112	203
PD	100.00	100.00	100.00	99.48	100.00	98.25	100.00	100.00	100.00
ID Rel.	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Alt. Rel.	100.00	100.00	100.00	100.00	100.00	100.00	98.91	100.00	100.00
RpyRpt	1	1	1	1	1	1	1	1	1
9point Range Mean (ft.)	0.0	-0.1	-0.1	-1.6	0.1	0.4	0.0	-0.8	-0.4
9point Range SD (ft.)	21.8	62.7	49.2	69.2	49.5	39.4	17.9	35.2	26.6
9point Azimuth Mean (deg.)	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000
9point Azimuth SD (deg.)	0.031	0.032	0.032	0.034	0.031	0.058	0.081	0.062	0.037

	Inflatable	Inflatable	Inflatable	Inflatable	Inflatable	Inflatable	FGAR	FGAR	FGAR	FGAR	FGAR	FGAR
Track No. (SFN)	110	114	20	405	647	72	196	358	466	18	445	419
Mode 3/A	7374	2756	7355	5736	3542	1673	2776	3460	6714	1631	0503	7343
Mode S Id	a057b9	a0aa6d	ab1654	a12ae7	a0ccca	a975fe	aa2ba7	accd1c	ad2b36	acb621	a2aa46	a44831
Mode S/ATCRBS (S/A)	S	S	S	S	S	S	S	S	S	S	S	S
Radial/Tangential (R/T)	R	R	R	R	R	R	R	R	R	R	R	R
Range (nmi)	31-200	25-140	38-117	200-27	155-199	35-199	128-200	115-199	197-61	77-200	93-65	150-63
Azimuth (deg.)	89-207	181-205	193-252	284-312	9-322	238-132	350-329	323-287	301-353	286-277	228-20	52-220
Altitude (100s ft.)	390-390	180-180	188-61	270-11	350-350	240-35	279-280	350-350	370-109	210-309	313-17	276-134
Scans	194	207	126	199	121	167	84	120	135	113	169	112
PD	98.97	98.07	100.00	100.00	100.00	99.40	100.00	100.00	100.00	100.00	100.00	100.00
ID Rel.	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Alt. Rel.	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.26	100.00	100.00	100.00
RpyRpt	1	1	1	1	1	1	1	1	1	1	1	1
9point Range Mean (ft.)	-0.1	-0.1	-0.2	0.1	0.0	4.1	0.7	-3.3	-0.1	-0.3	-0.4	0.0
9point Range SD (ft.)	19.0	25.8	74.5	89.1	45.4	56.4	36.0	41.9	76.2	41.5	47.4	78.1
9point Azimuth Mean (deg.)	0.000	0.000	0.000	0.000	0.000	0.001	0.001	-0.001	0.000	0.000	0.000	0.000
9point Azimuth SD (deg.)	0.029	0.030	0.042	0.047	0.046	0.037	0.062	0.032	0.043	0.039	0.031	0.036

	Inflatable	Inflatable	Inflatable	Inflatable	FGAR	FGAR	FGAR	FGAR	FGAR	FGAR
Track No. (SFN)	722	759	107	724	761	197	490	452	188	9
Mode 3/A	1740	3067	1777	2676	1442	3007	2663	0547	7312	3501
Mode S/ATCRBS (S/A)	A	A	A	A	A	A	A	A	A	A
Radial/Tangential (R/T)	T	T	T	T	T	T	T	T	T	T
Range (nmi)	41-147	79-93	43-169	199-84	88-123	174-200	124-122	83-79	85-91	130-112
Azimuth (deg.)	331-207	37-263	86-204	314-4	52-203	319-278	327-2	246-50	61-238	341-275
Altitude (100s ft.)	6-280	30-349	234-996	370-36	326-431	208-390	70-70	170	280-100	160-99
Scans	181	172	205	135	167	134	147	182	81	203
PD	99.45	99.42	99.02	97.78	100.00	89.55	95.24	100.00	100.00	100.00
ID Rel.	98.89	99.42	92.12	93.18	100.00	97.50	96.43	99.45	100.00	98.52
ID Val.	99.44	98.83	91.63	87.12	100.00	95.00	93.57	98.90	100.00	98.03
Alt. Rel.	98.33	98.83	91.63	93.94	100.00	95.00	97.14	99.45	98.51	98.03
Alt. Val.	95.56	95.91	85.22	84.09	99.40	92.50	91.43	96.70	96.53	94.09
RpyRpt	5.6	5.8	5.5	5.1	6.3	4.6	5	5.4	6.3	5.7
9point Range Mean (ft.)	-7.3	2.8	0.5	-2.8	-0.3	-2.7	-1.2	0.5	0.1	-0.6
9point Range SD (ft.)	80.5	72.8	39.5	21.4	24.5	32.3	32.7	34.5	75.5	42.9
9point Azimuth Mean (deg.)	0.001	0.001	0.001	-0.002	-0.003	0.001	0.003	0.000	0.002	0.000
9point Azimuth SD (deg.)	0.043	0.020	0.042	0.072	0.088	0.061	0.044	0.087	0.042	0.050

	Inflatable	Inflatable	Inflatable	Inflatable	Inflatable	Inflatable	FGAR	FGAR	FGAR	FGAR	FGAR
Track No. (SFN)	154	195	528	202	640	561	652	614	157	203	623
Mode 3/A	0533	3465	2030	3073	5132	3050	6031	6564	1706	5514	7407
Mode S/ATCRBS (S/A)	A	A	A	A	A	A	A	A	A	A	A
Radial/Tangential (R/T)	R	R	R	R	R	R	R	R	R	R	R
Range (nmi)	45-143	25-116	157-14	23-102	89-83	5-123	161-33	112-89	36-189	70-128	146-20
Azimuth (deg.)	73-53	203-226	42-294	211-207	262-16	253-210	298-335	210-44	240-210	315-259	284-312
Altitude (100s ft.)	210-116	159-159	159-59	60-60	57-175	217-348	268-2	293-158	172-227	100-165	210
Scans	118	207	206	207	205	81	165	169	68	203	203
PD	97.46	99.52	95.63	98.55	99.51	100.00	100.00	100.00	100.00	100.00	99.01
ID Rel.	99.13	97.57	98.98	98.53	99.02	100.00	98.18	100.00	100.00	97.54	97.51
ID Val.	99.13	96.60	99.49	97.06	98.04	100.00	98.18	100.00	100.00	98.03	98.01
Alt. Rel	99.13	97.09	98.48	100.00	98.04	100.00	96.97	100.00	98.77	95.07	97.01
Alt. Val.	93.91	91.26	94.42	95.10	96.57	98.31	93.33	99.41	98.16	93.60	95.52
RpyRpt	5.9	5.6	6	6.2	5.9	5.6	5.9	6.2	5.9	5.6	6
9point Range Mean (ft.)	0.0	-0.2	-0.4	-0.5	1.0	4.0	0.0	-5.5	-0.1	0.5	0.8
9point Range SD (ft.)	29.2	23.9	47.9	19.6	40.7	36.8	50.8	65.8	40.2	20.6	67.0
9point Azimuth Mean (deg.)	0.000	0.000	0.002	0.001	0.002	0.003	0.000	0.001	0.000	0.000	0.002
9point Azimuth SD (deg.)	0.036	0.040	0.046	0.032	0.048	0.036	0.079	0.067	0.087	0.050	0.045

TABLES 4/5/6/7

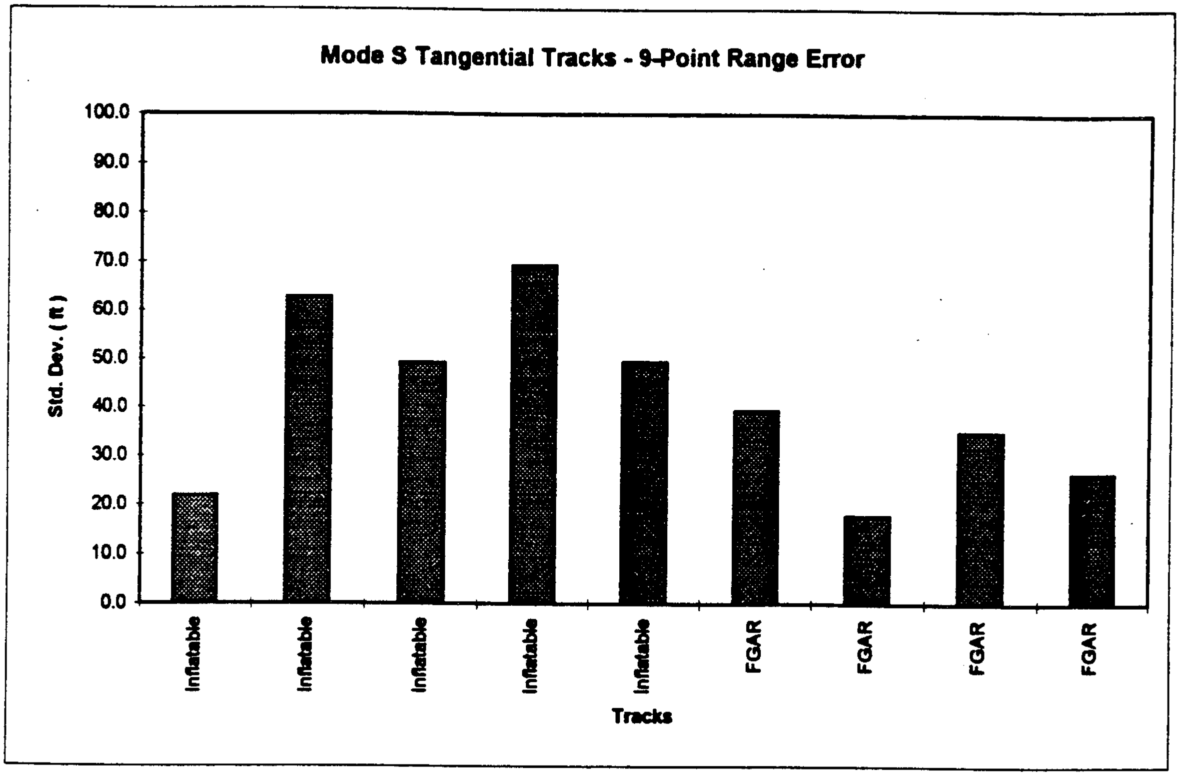


FIGURE 13

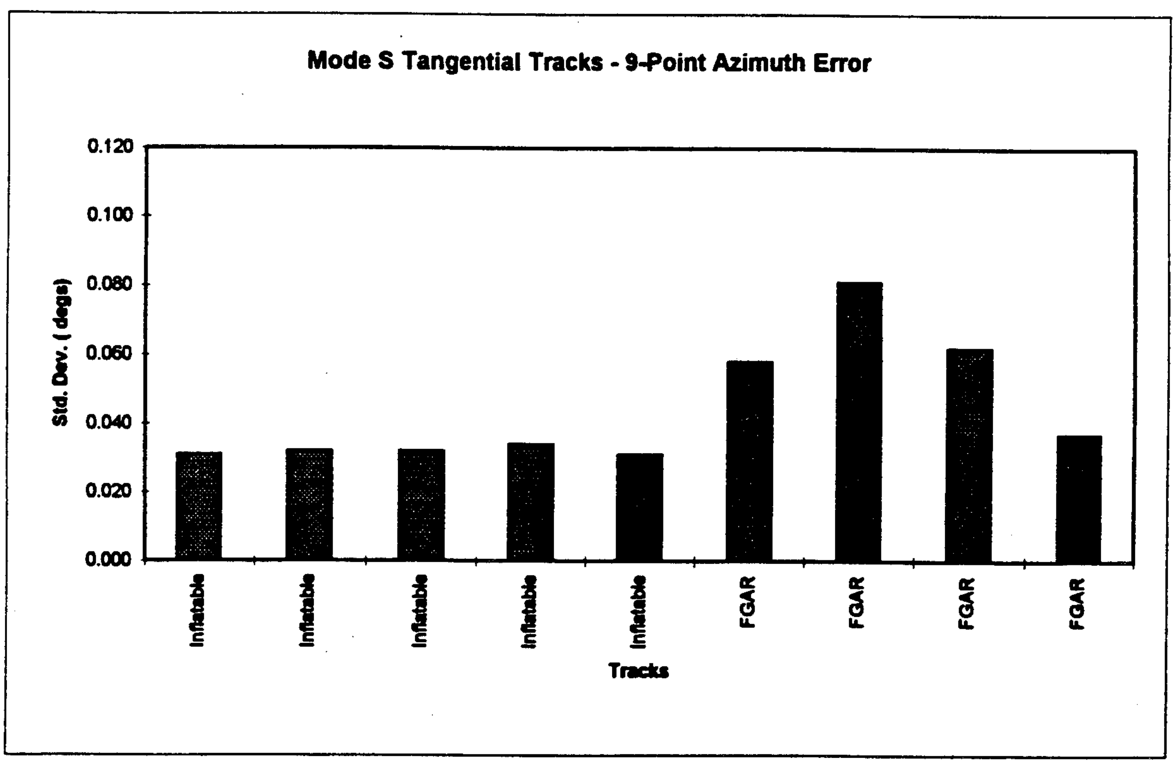


FIGURE 14

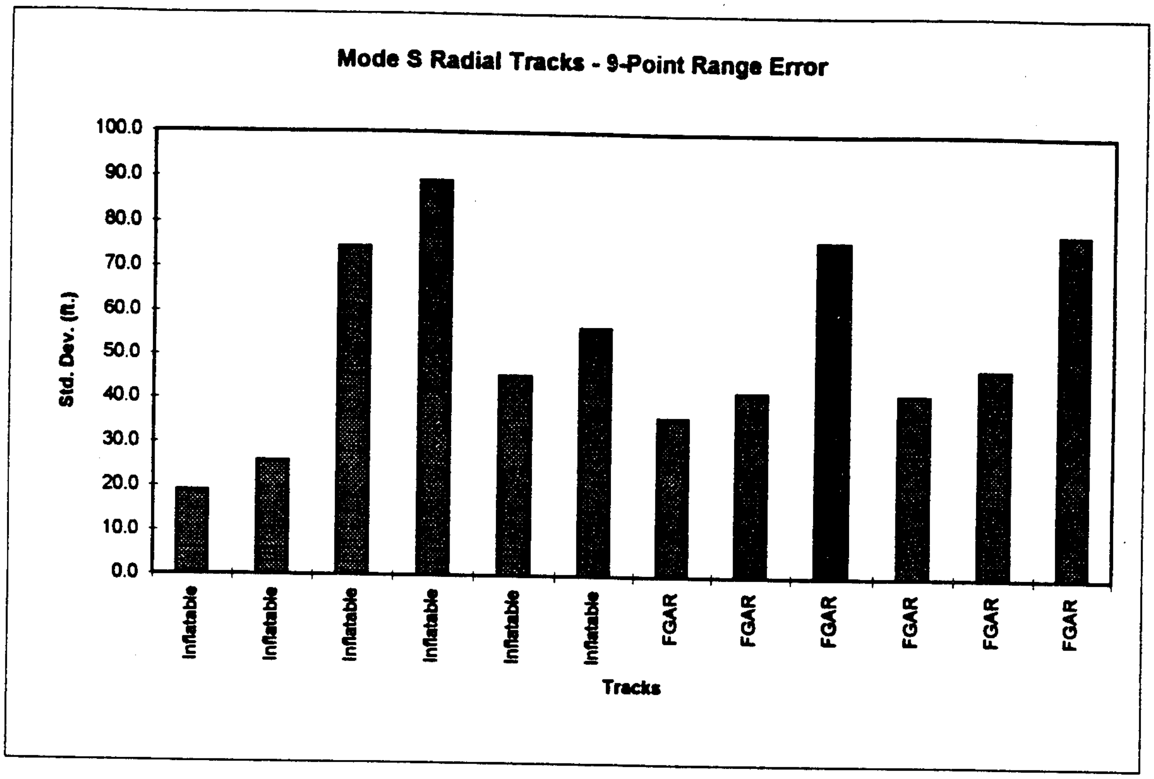


FIGURE 15

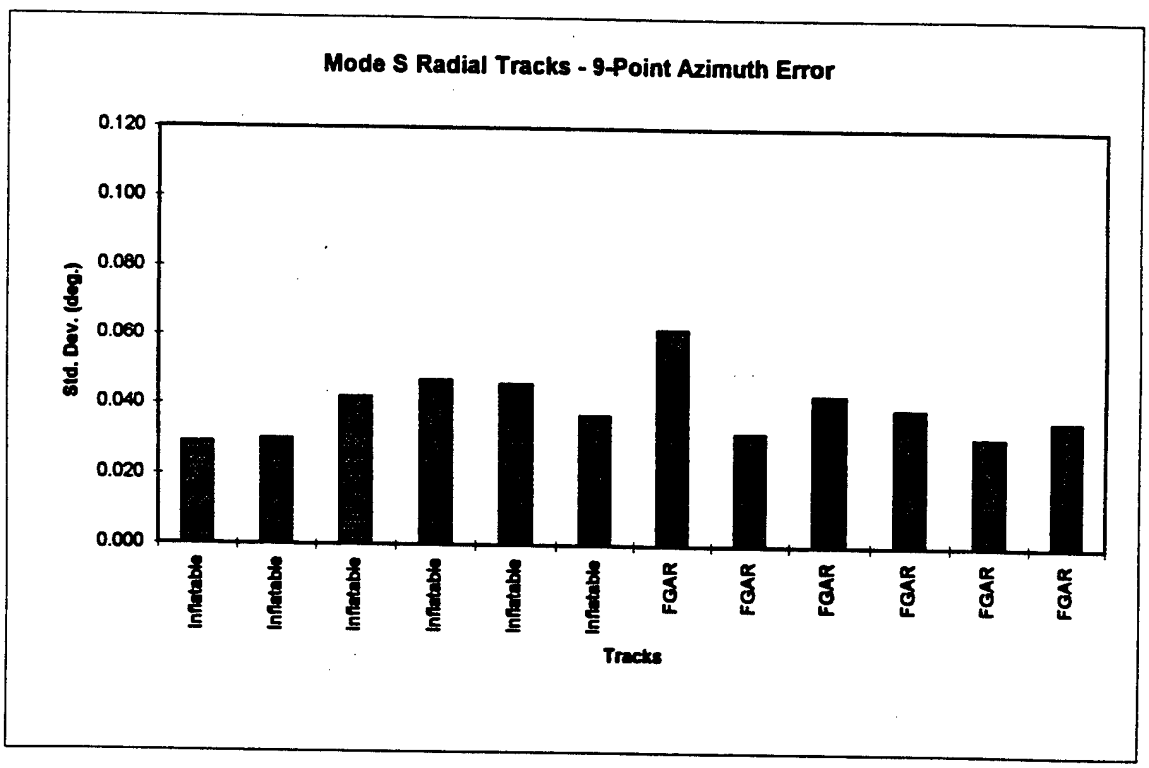


FIGURE 16

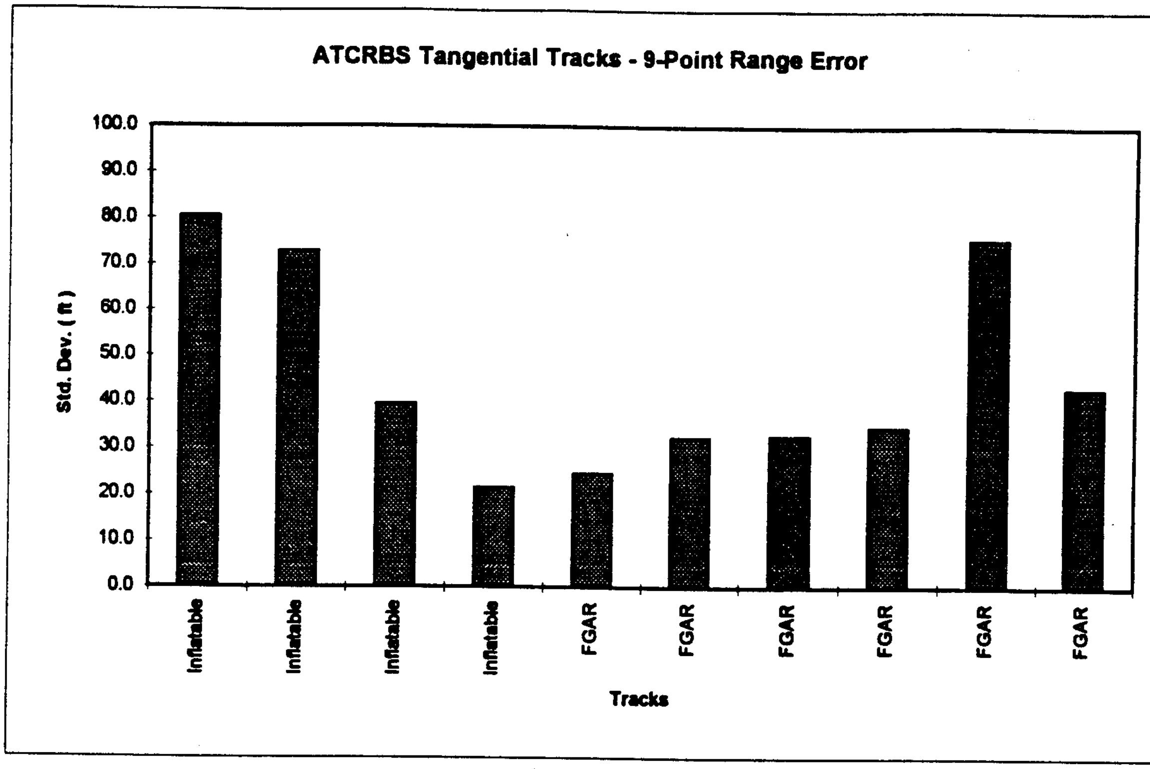


FIGURE 17

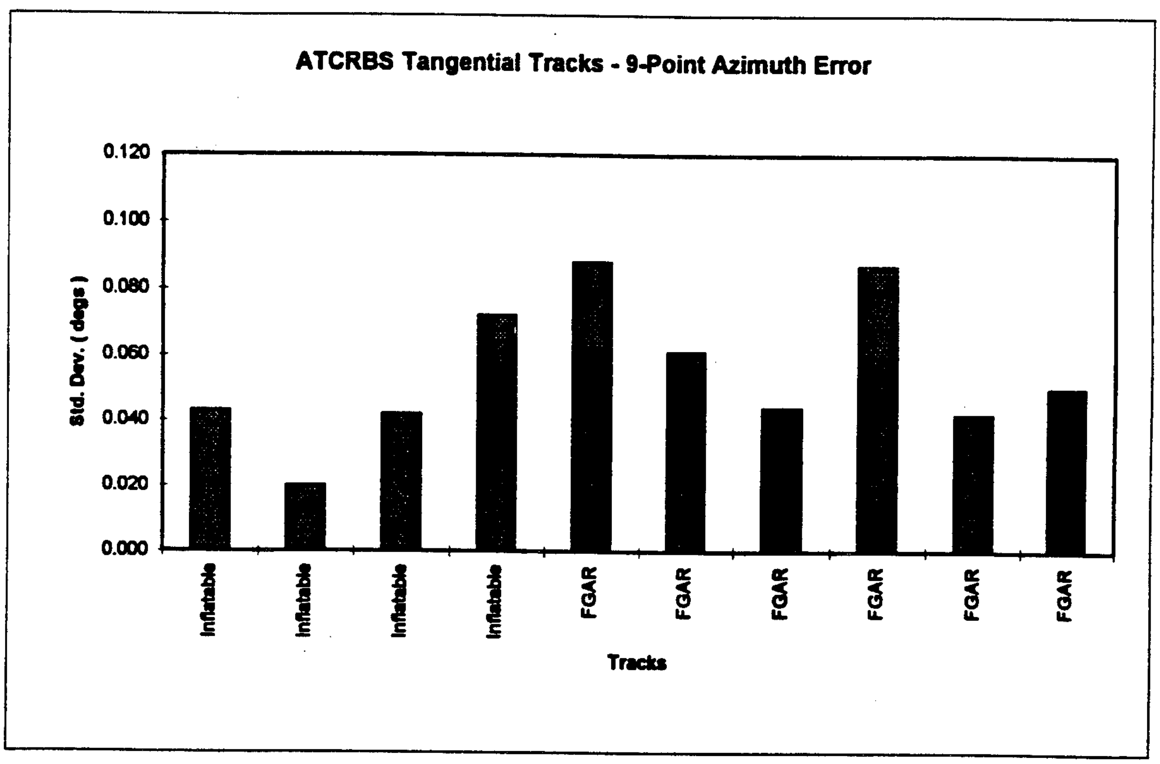


FIGURE 18

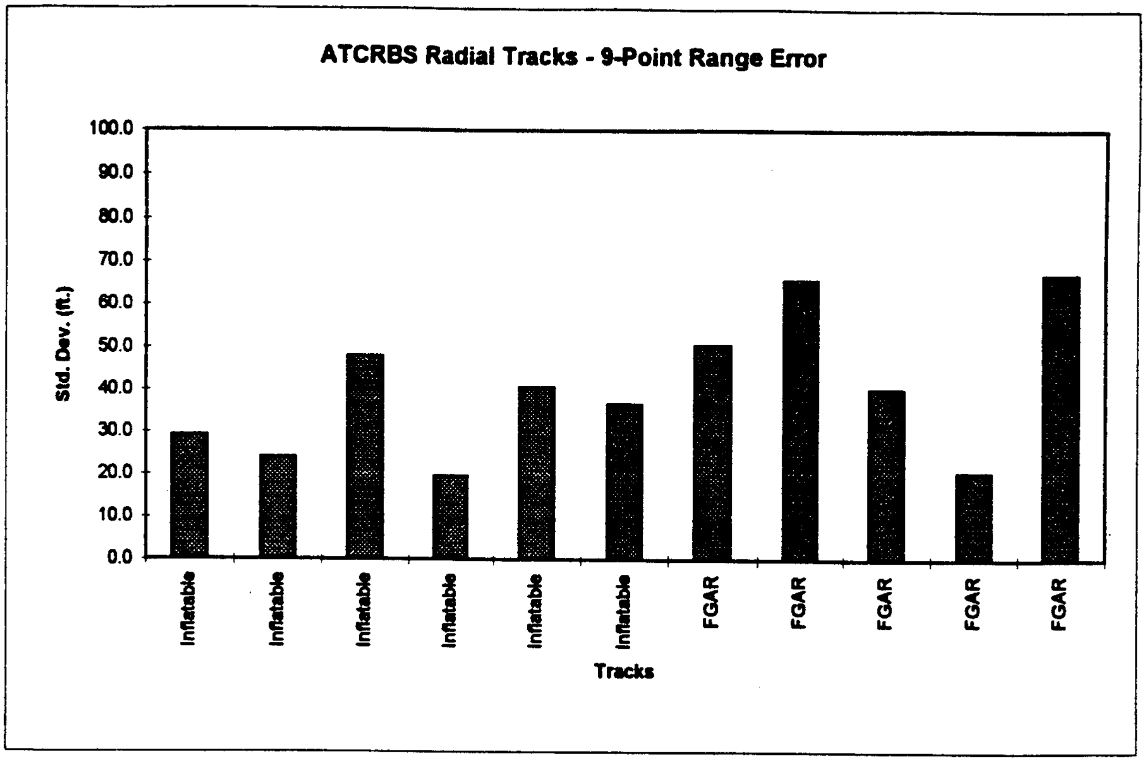


FIGURE 19

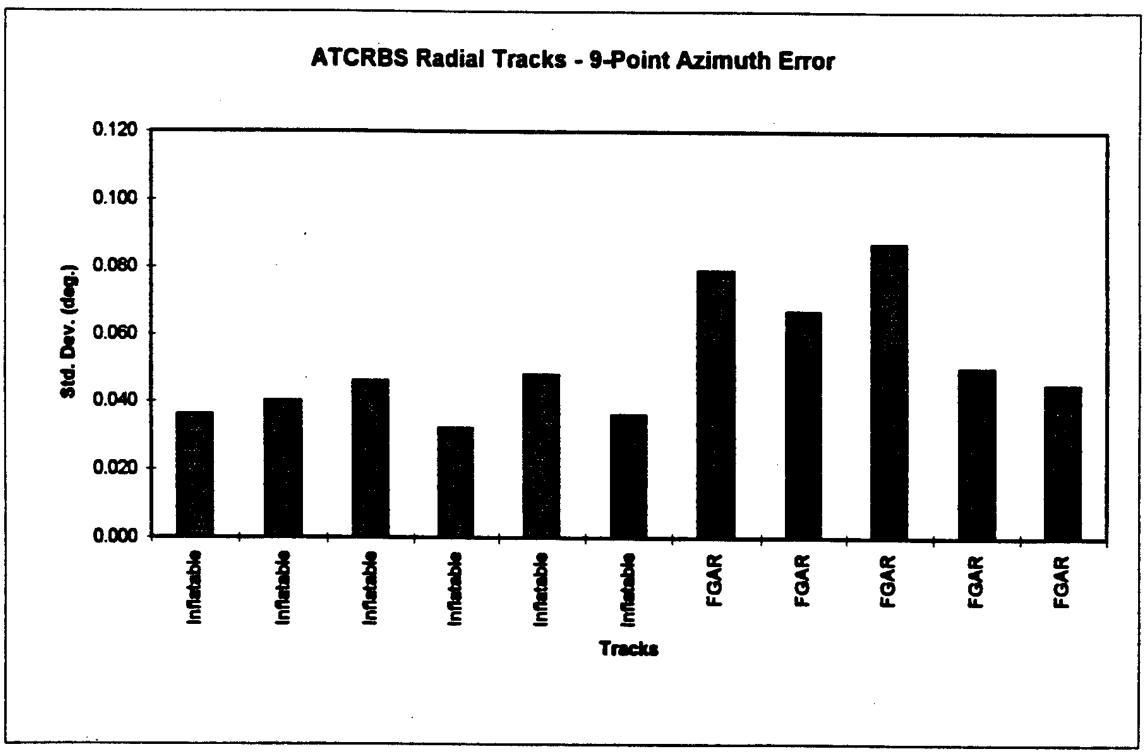
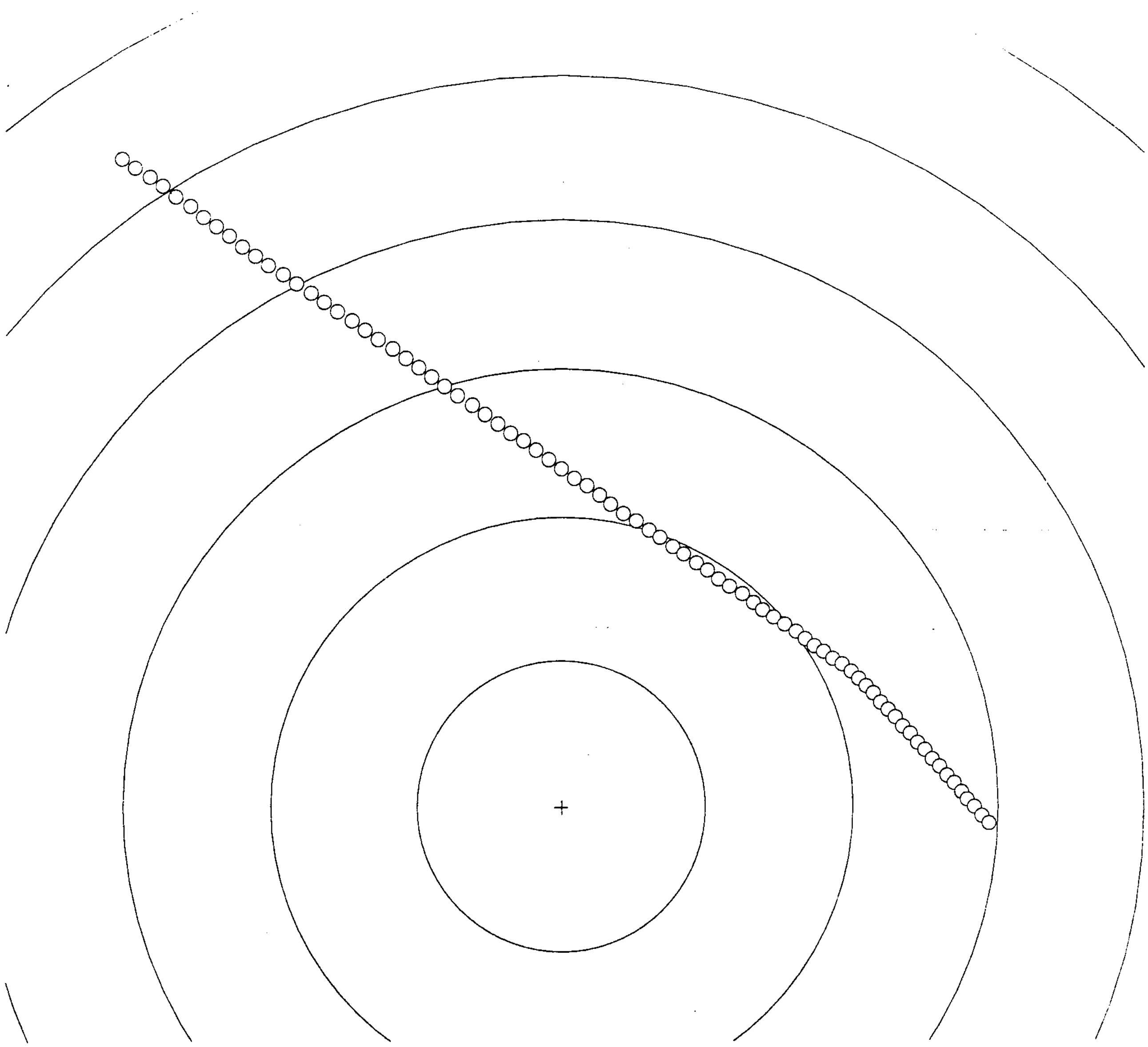


FIGURE 20

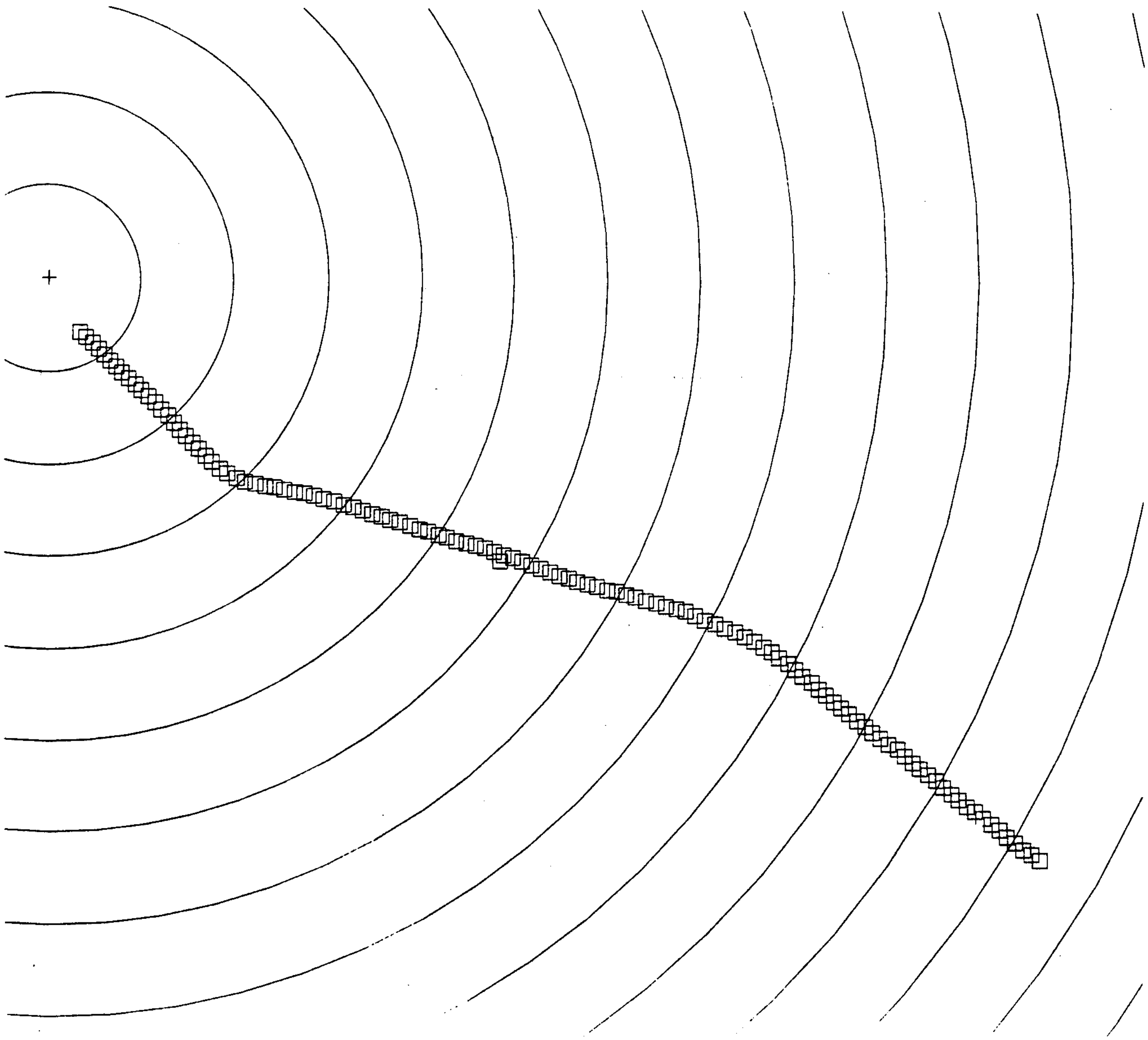


INFLATABLE

Mode S

ID	**A0BF7C**
3/A Code	**0510**

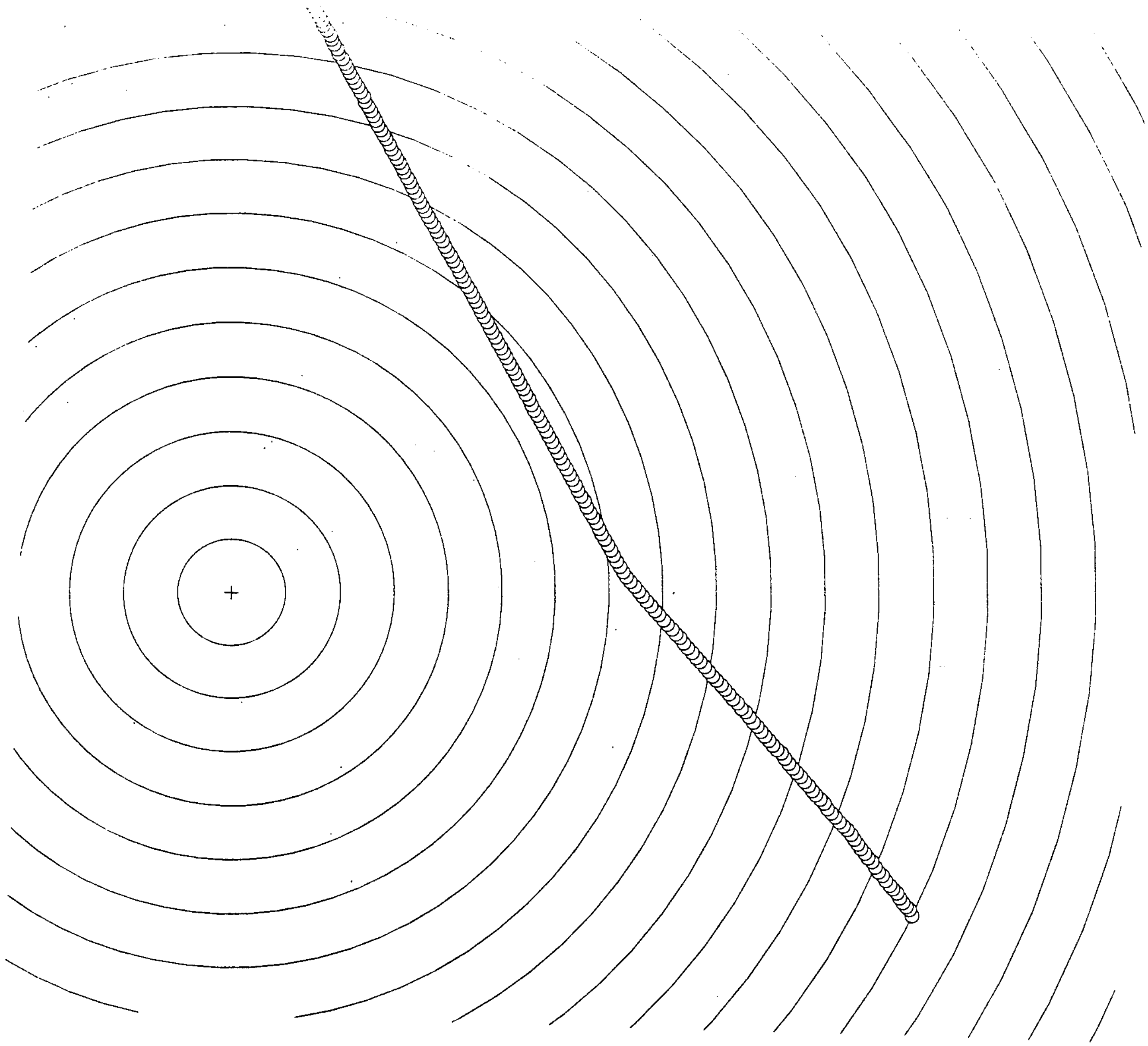
FIGURE 21



INFLATABLE

ATCRBS
3/A Code 3050

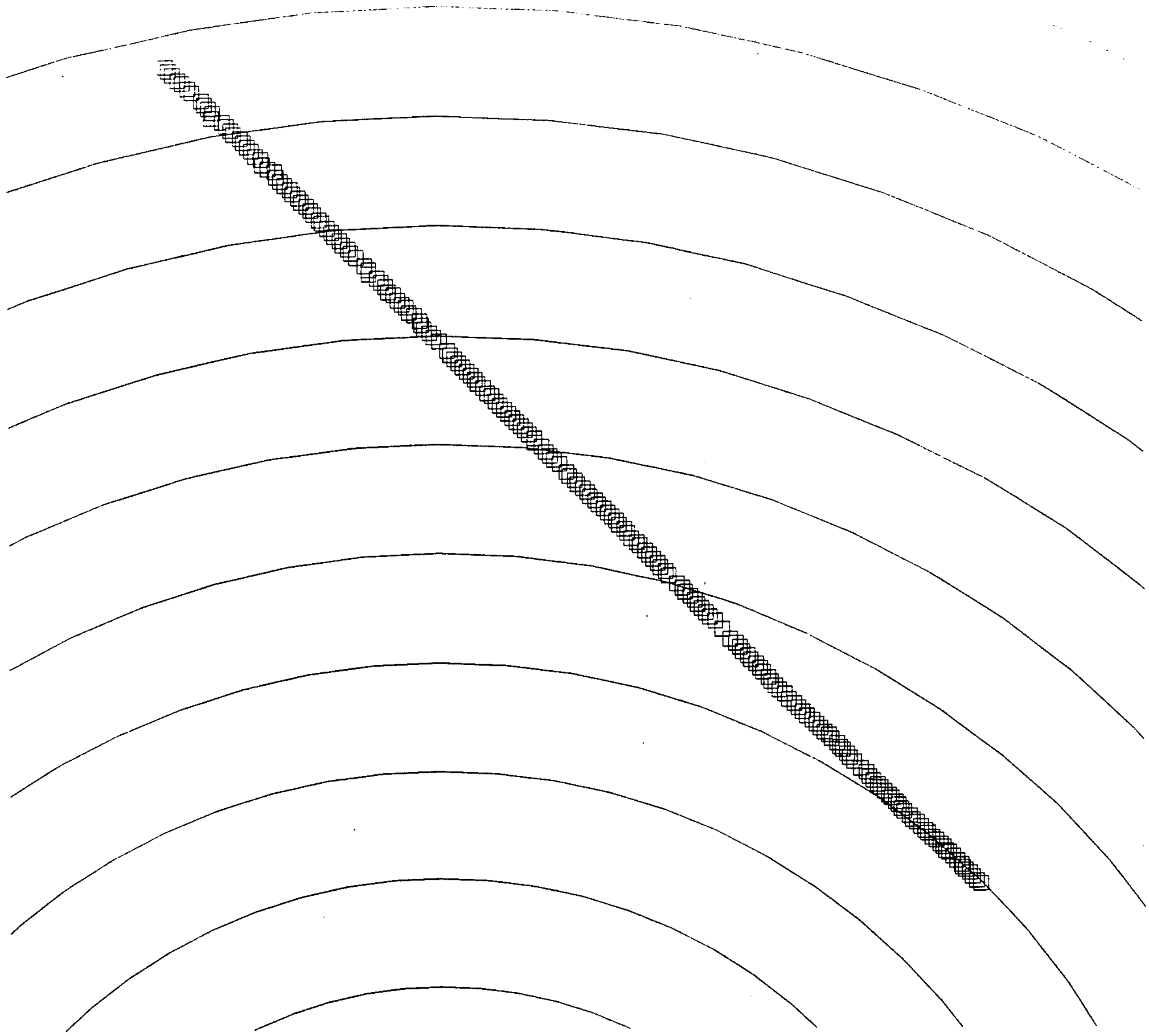
FIGURE 22



FGAR

ID	**A00676**
3/A Code	**7367**

FIGURE 23



FGAR

ATCRBS
3/A Code 5514

FIGURE 24

	Date	Fruit Replies		Average Fruit		Fruit Rate		Sample
		ATCRBS	Mode S	ATCRBS	Mode S	ATCRBS	Mode S	Scans
Inflatable	9/12/94	192000	10514	936.6	51.3	478.1	26.2	205
Inflatable	9/13/94	240274	13271	1044.7	57.7	532.9	29.4	230
Inflatable	9/14/94	207761	11078	1013.5	54	517	27.6	205
Inflatable	9/15/94	178279	8521	788.8	37.7	402.7	19.2	226
Inflatable	9/16/94	184902	10110	836.7	45.7	427.1	23.4	221
Inflatable	9/19/94	183807	16497	785.5	70.5	401.3	36	234
Inflatable	9/20/94	167080	9258	788.1	43.7	402.3	22.3	212
FGAR	10/17/94	232607	11032	877.8	41.6	448.5	21.3	265
FGAR	10/18/94	147343	9274	685.3	43.1	350.1	22	215
FGAR	10/19/94	241735	11287	1140.3	53.2	582.6	27.2	212
FGAR	10/20/94	142601	5242	672.6	24.7	343.7	12.6	212
FGAR	10/21/94	171369	9044	844.2	44.6	431.3	22.8	203
FGAR, Wet	12/6/94	168982	6894	824.3	33.6	421.2	17.2	205

TABLE 11

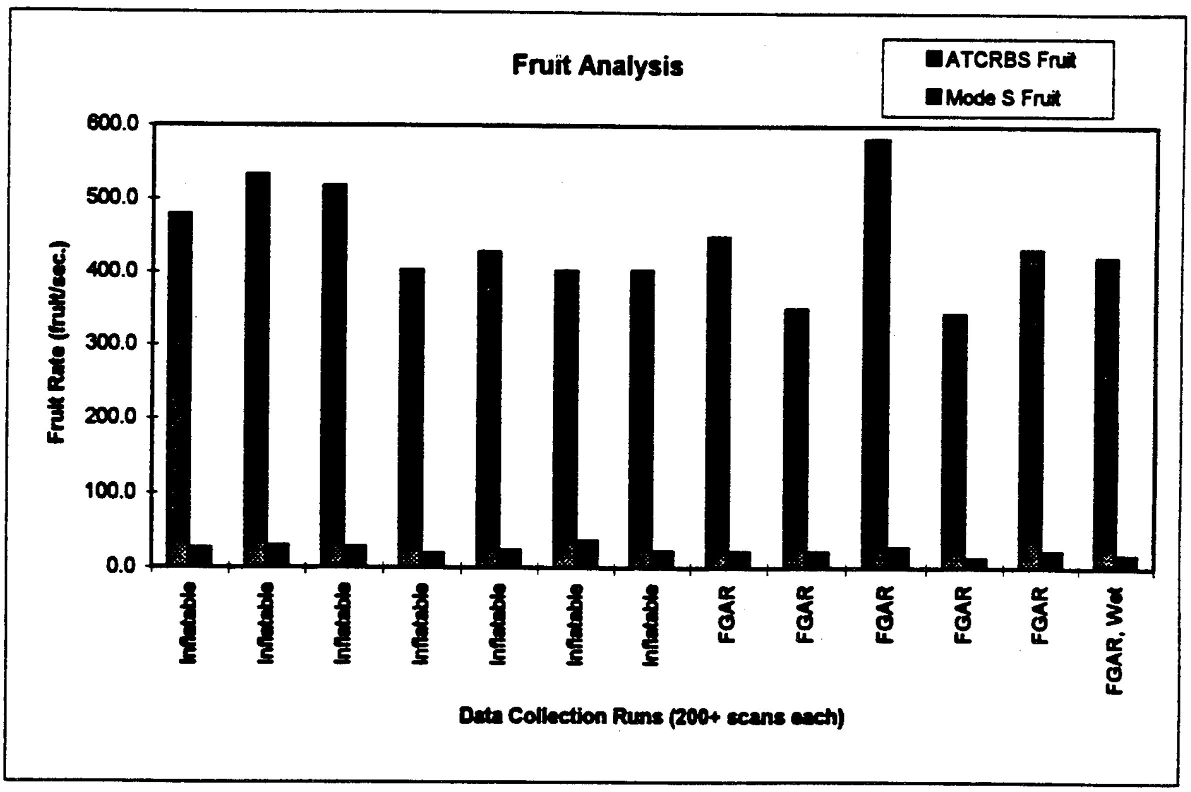
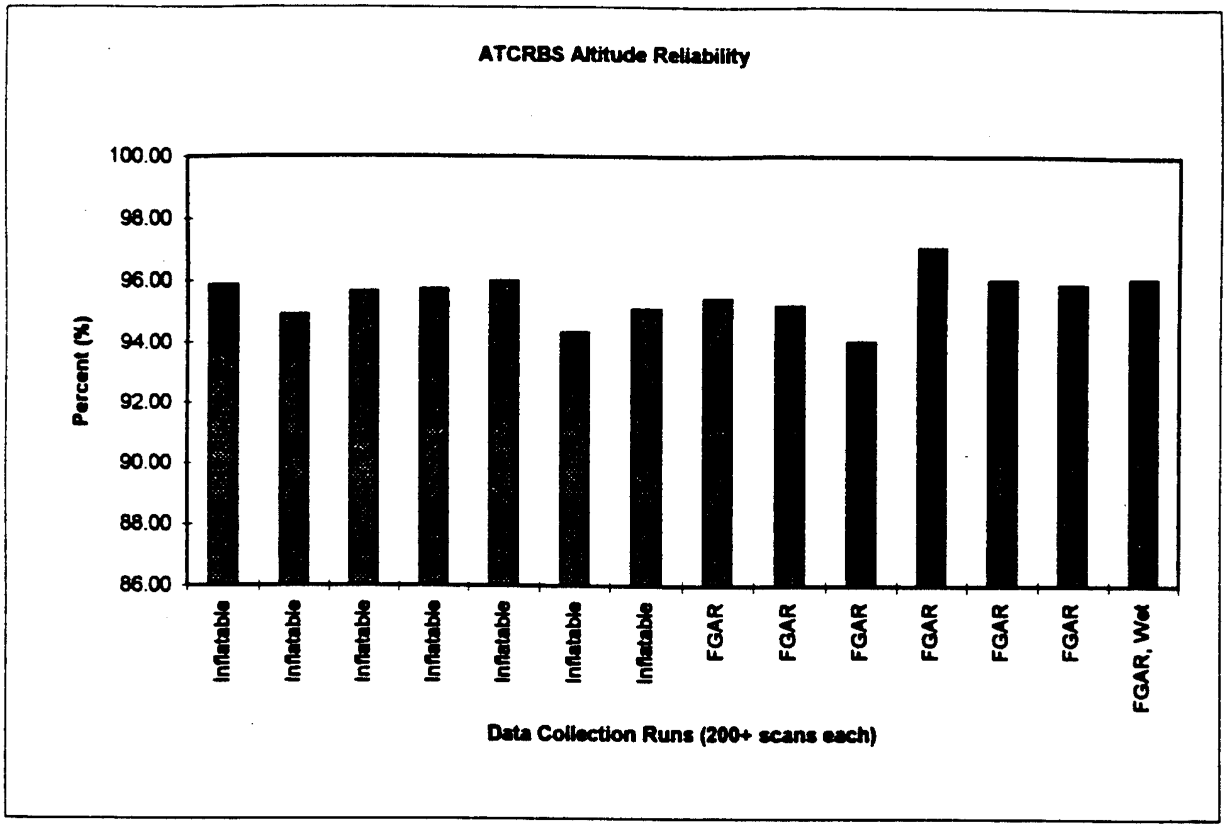
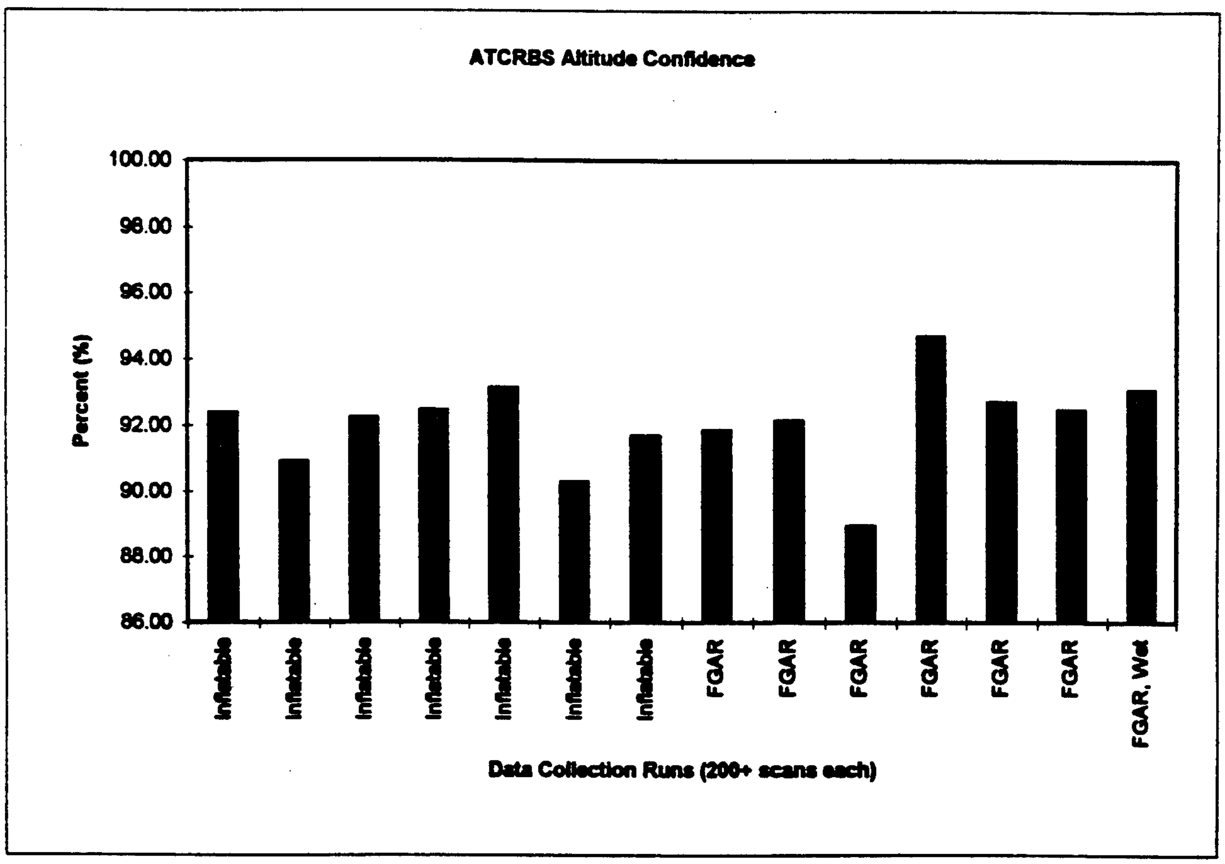
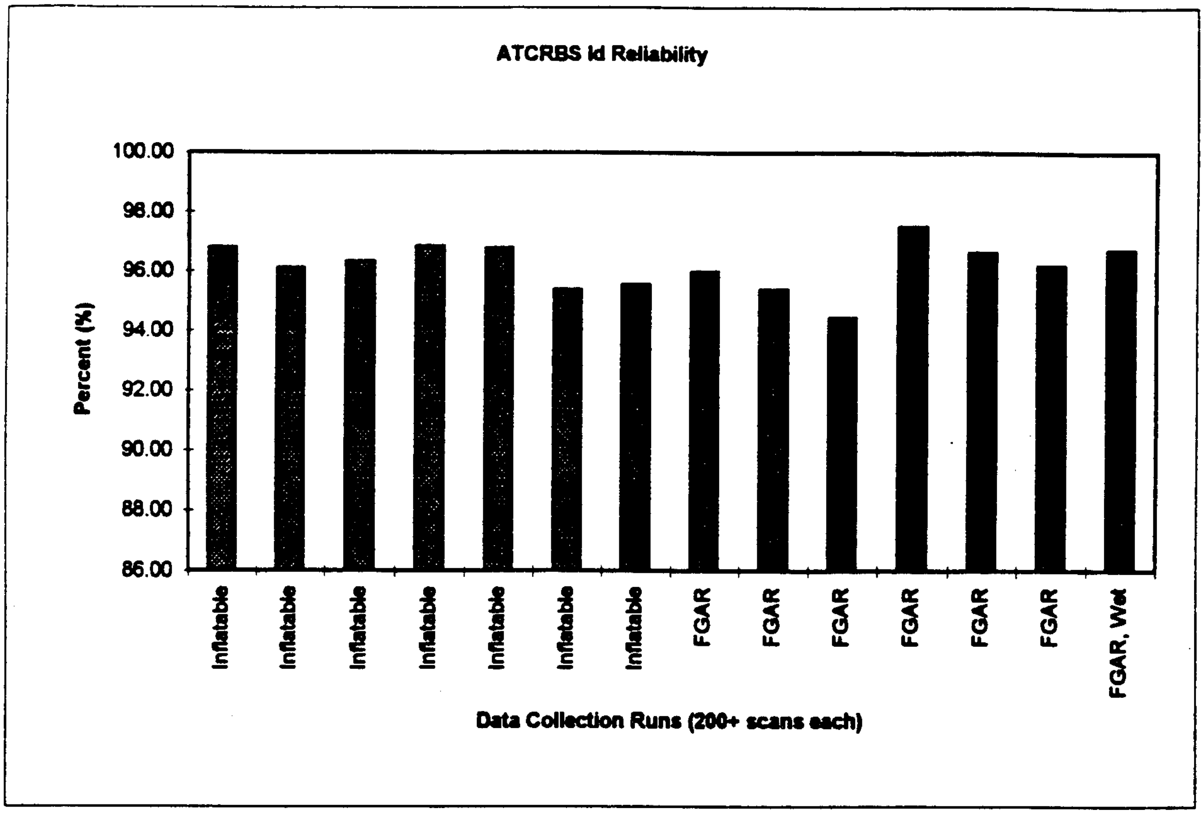


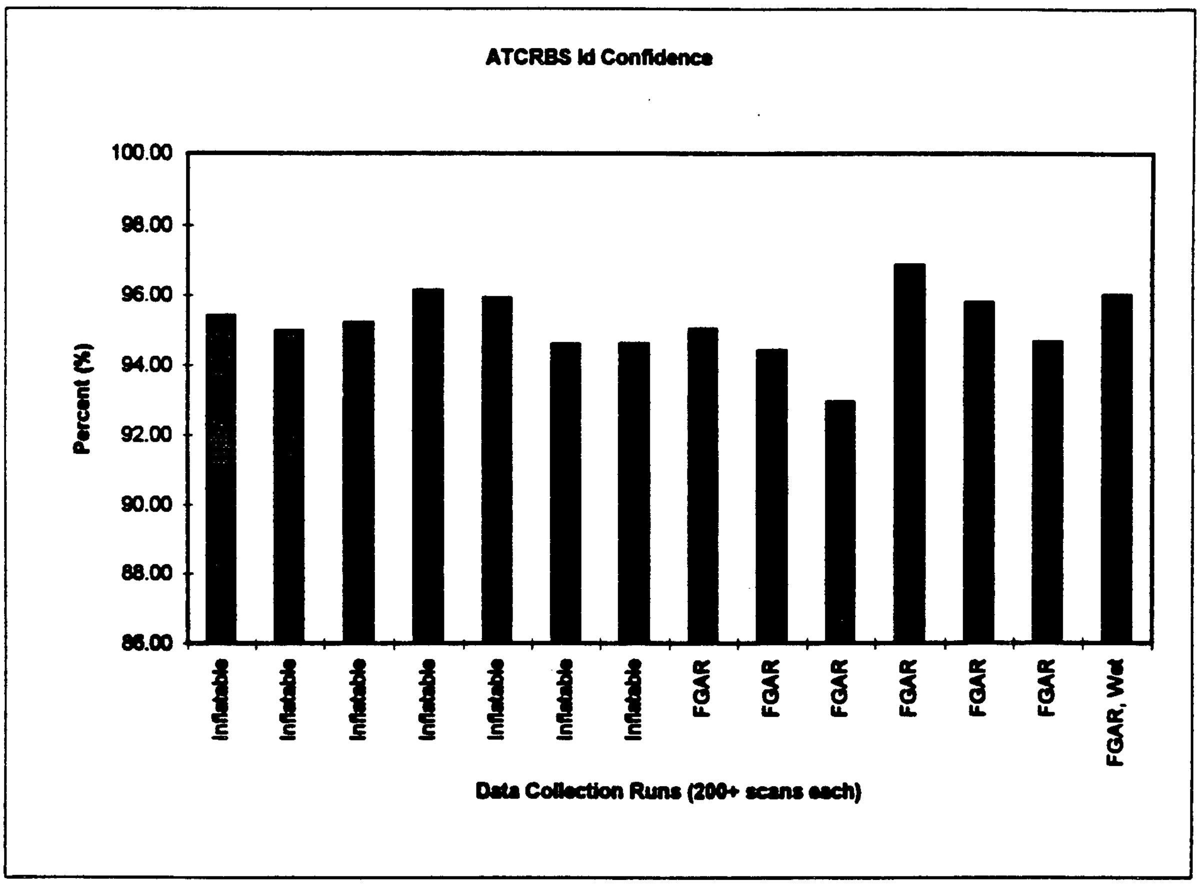
FIGURE 34



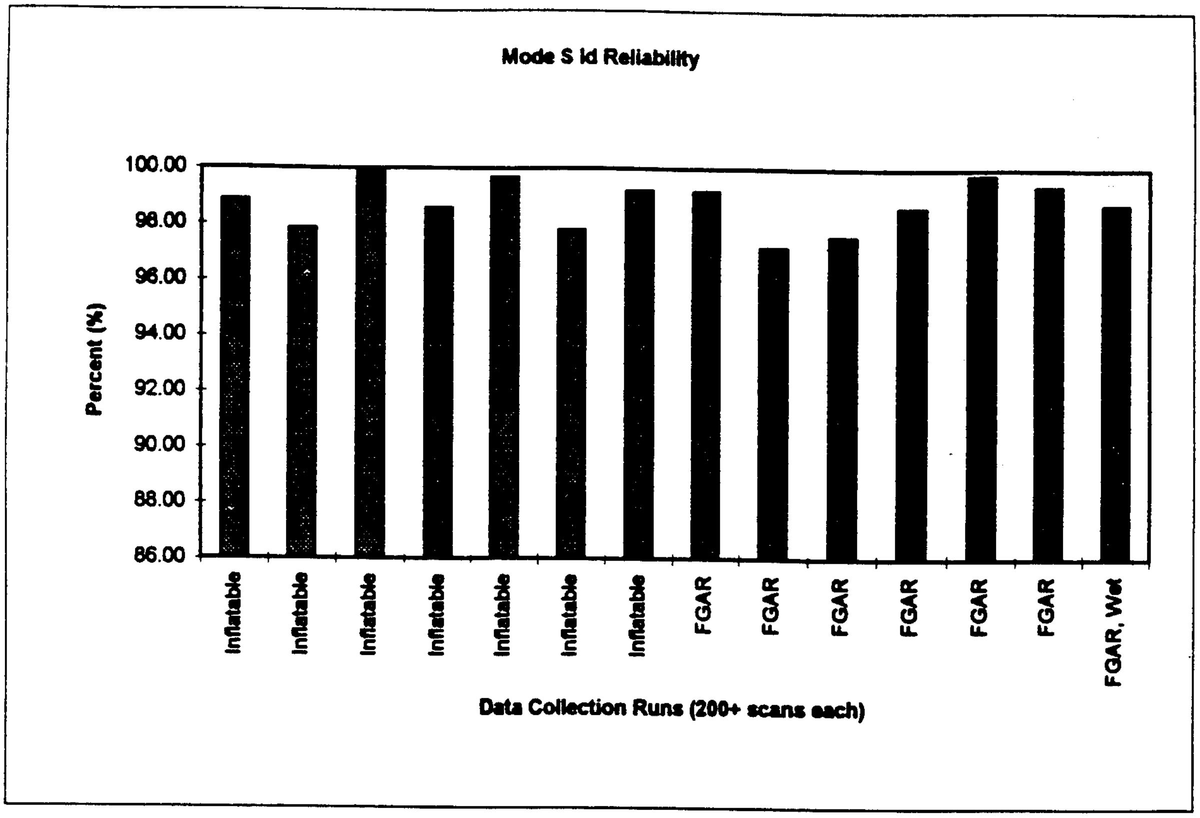


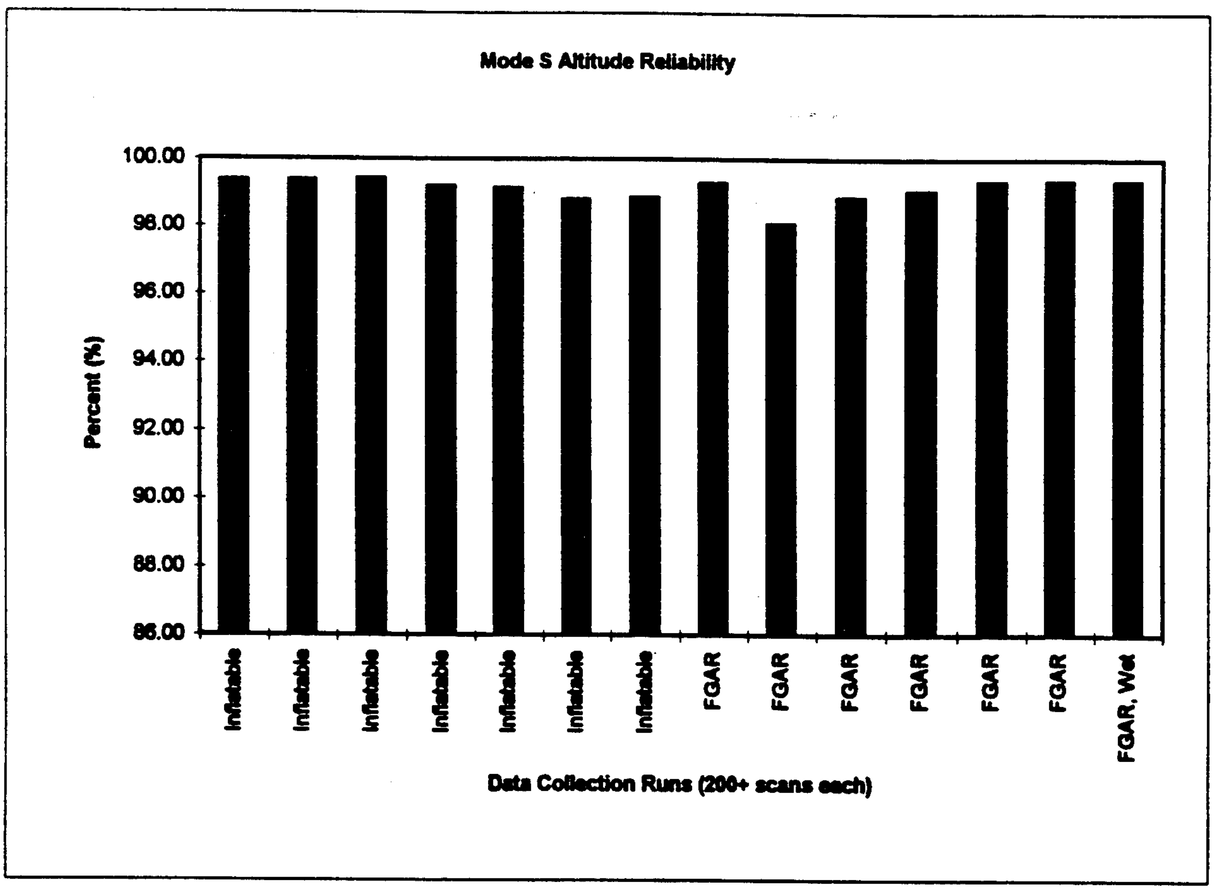
FIGURES 32 & 33



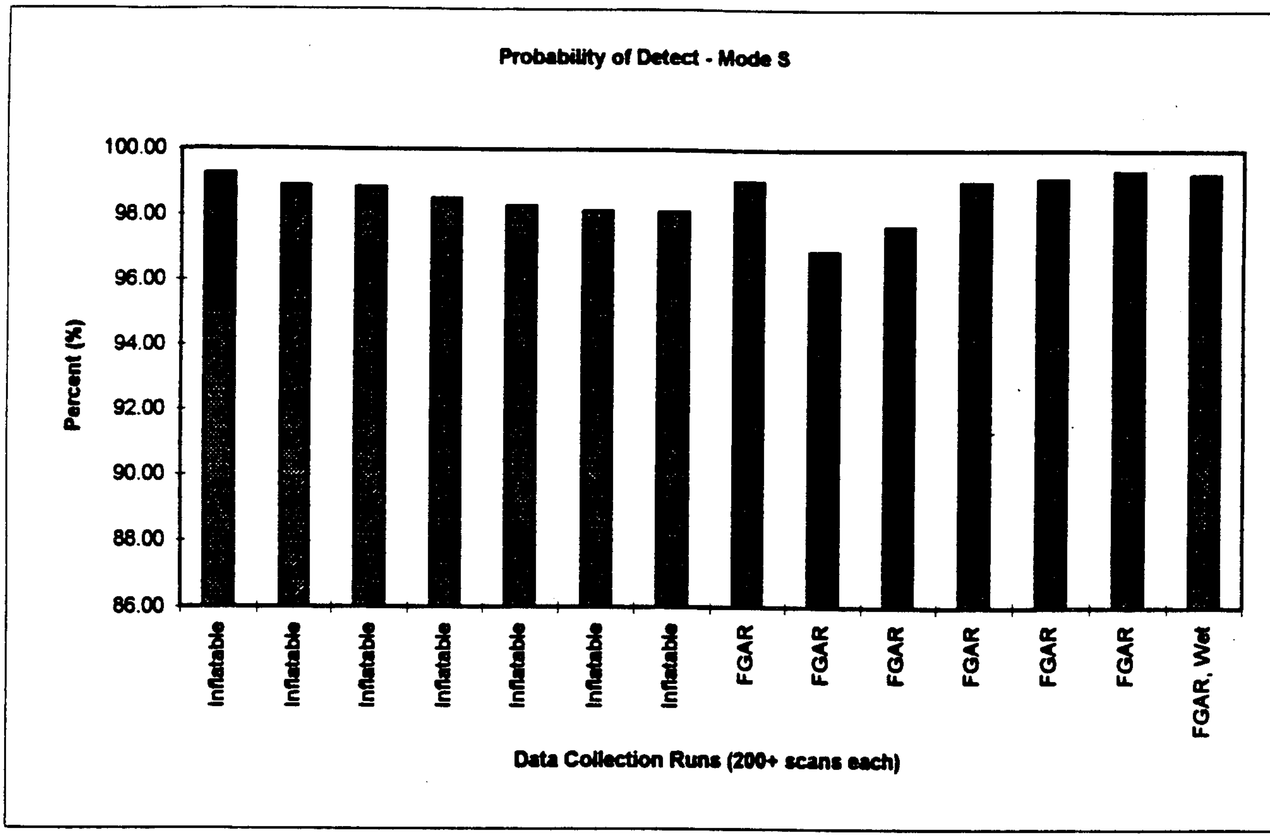


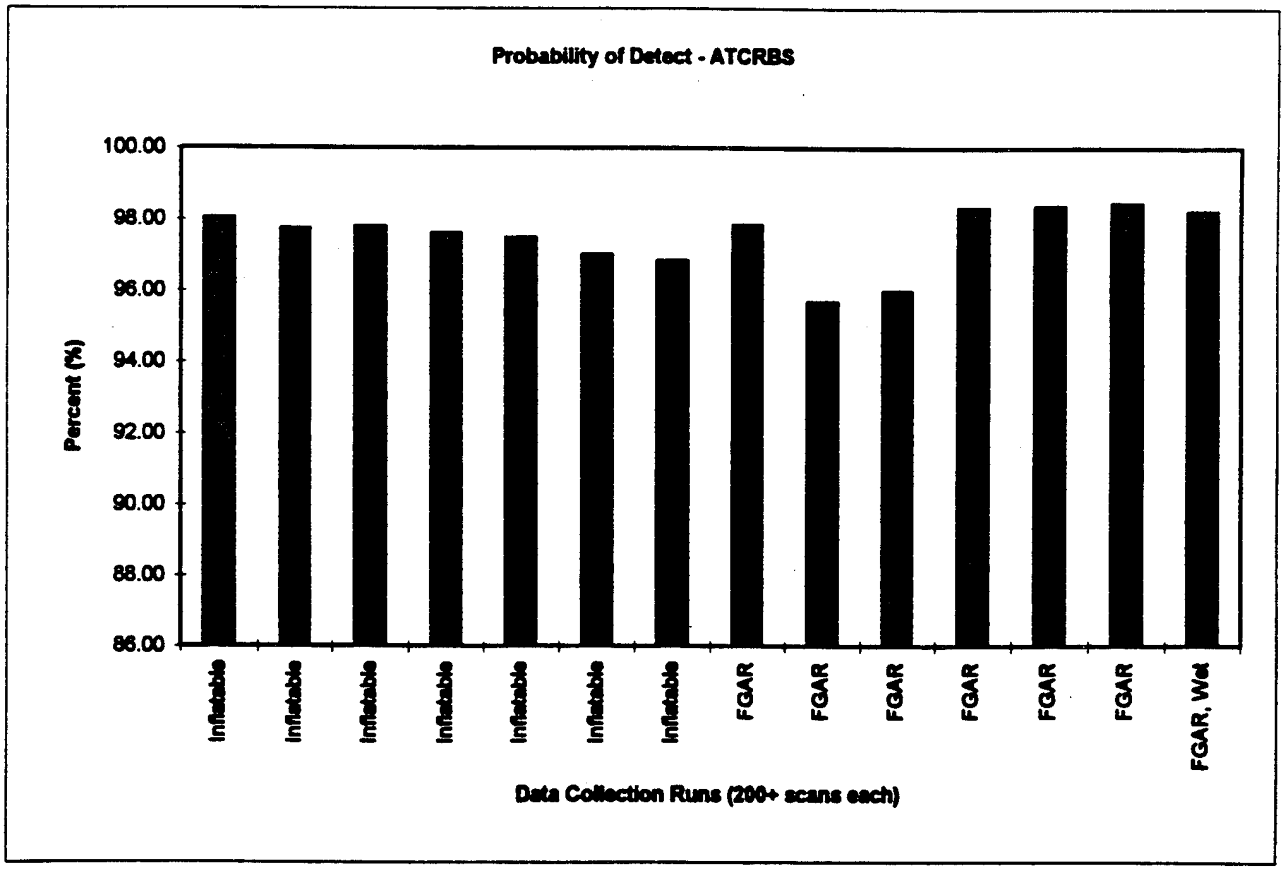
FIGURES 30 & 31





FIGURES 28 & 29





FIGURES 26 & 27

		Total					
	Date	Track Life	Beacon Pd	Id Rel.	Id Conf.	Alt. Rel.	Alt. Conf.
Inflatable	9/12/94	116915	98.51	97.60	95.41	97.26	92.39
Inflatable	9/13/94	124862	98.16	96.76	94.97	96.59	90.89
Inflatable	9/14/94	115379	98.19	97.72	95.21	97.12	92.23
Inflatable	9/15/94	93258	97.96	97.53	96.13	97.13	92.46
Inflatable	9/16/94	100996	97.81	97.97	95.92	97.30	93.14
Inflatable	9/19/94	109406	97.49	96.38	94.59	96.19	90.29
Inflatable	9/20/94	102938	97.31	96.92	94.62	96.51	91.69
FGAR	10/17/94	138452	98.32	97.26	95.03	96.98	91.86
FGAR	10/18/94	100433	96.18	96.10	94.41	96.37	92.15
FGAR	10/19/94	103328	96.63	95.64	92.94	95.90	88.94
FGAR	10/20/94	79080	98.58	97.92	96.85	97.82	94.69
FGAR	10/21/94	103895	98.69	97.98	95.79	97.43	92.72
FGAR	10/27/94	115099	98.78	97.38	94.67	97.18	92.48
FGAR. Wet	12/6/94	103169	98.63	97.45	96.00	97.31	93.07

		Mode S					
	Date	Track Life	Beacon Pd	Id Rel.	Id Conf.	Alt. Rel.	Alt. Conf.
Inflatable	9/12/94	45850	99.26	98.86	n/a	99.37	n/a
Inflatable	9/13/94	46761	98.87	97.84	n/a	99.36	n/a
Inflatable	9/14/94	44502	98.84	99.92	n/a	99.42	n/a
Inflatable	9/15/94	37524	98.48	98.56	n/a	99.20	n/a
Inflatable	9/16/94	41660	98.27	99.68	n/a	99.15	n/a
Inflatable	9/19/94	45094	98.14	97.78	n/a	98.80	n/a
Inflatable	9/20/94	38316	98.12	99.19	n/a	98.86	n/a
FGAR	10/17/94	54955	99.03	99.18	n/a	99.29	n/a
FGAR	10/18/94	40494	96.90	97.16	n/a	98.08	n/a
FGAR	10/19/94	39605	97.66	97.55	n/a	98.87	n/a
FGAR	10/20/94	30504	99.01	98.60	n/a	99.06	n/a
FGAR	10/21/94	44045	99.11	99.79	n/a	99.34	n/a
FGAR	10/27/94	42953	99.35	99.38	n/a	99.36	n/a
FGAR. Wet	12/6/94	38789	99.28	98.71	n/a	99.36	n/a

		ATCRBS					
	Date	Track Life	Beacon Pd	Id Rel.	Id Conf.	Alt. Rel.	Alt. Conf.
Inflatable	9/12/94	71065	98.03	96.79	95.41	95.87	92.39
Inflatable	9/13/94	78101	97.74	96.11	94.97	94.91	90.89
Inflatable	9/14/94	70877	97.78	96.33	95.21	95.65	92.23
Inflatable	9/15/94	55734	97.61	96.83	96.13	95.72	92.46
Inflatable	9/16/94	59336	97.49	96.76	95.92	95.99	93.14
Inflatable	9/19/94	64312	97.03	95.38	94.59	94.33	90.29
Inflatable	9/20/94	64622	96.84	95.55	94.62	95.09	91.69
FGAR	10/17/94	83497	97.85	95.99	95.03	95.43	91.86
FGAR	10/18/94	59939	95.69	95.38	94.41	95.19	92.15
FGAR	10/19/94	63723	95.98	94.43	92.94	94.02	88.94
FGAR	10/20/94	48576	98.32	97.50	96.85	97.04	94.69
FGAR	10/21/94	59850	98.38	96.64	95.79	96.01	92.72
FGAR	10/27/94	72146	98.44	96.18	94.67	95.86	92.48
FGAR. Wet	12/6/94	64380	98.24	96.69	96.00	96.05	93.07

TABLES 8/9/10

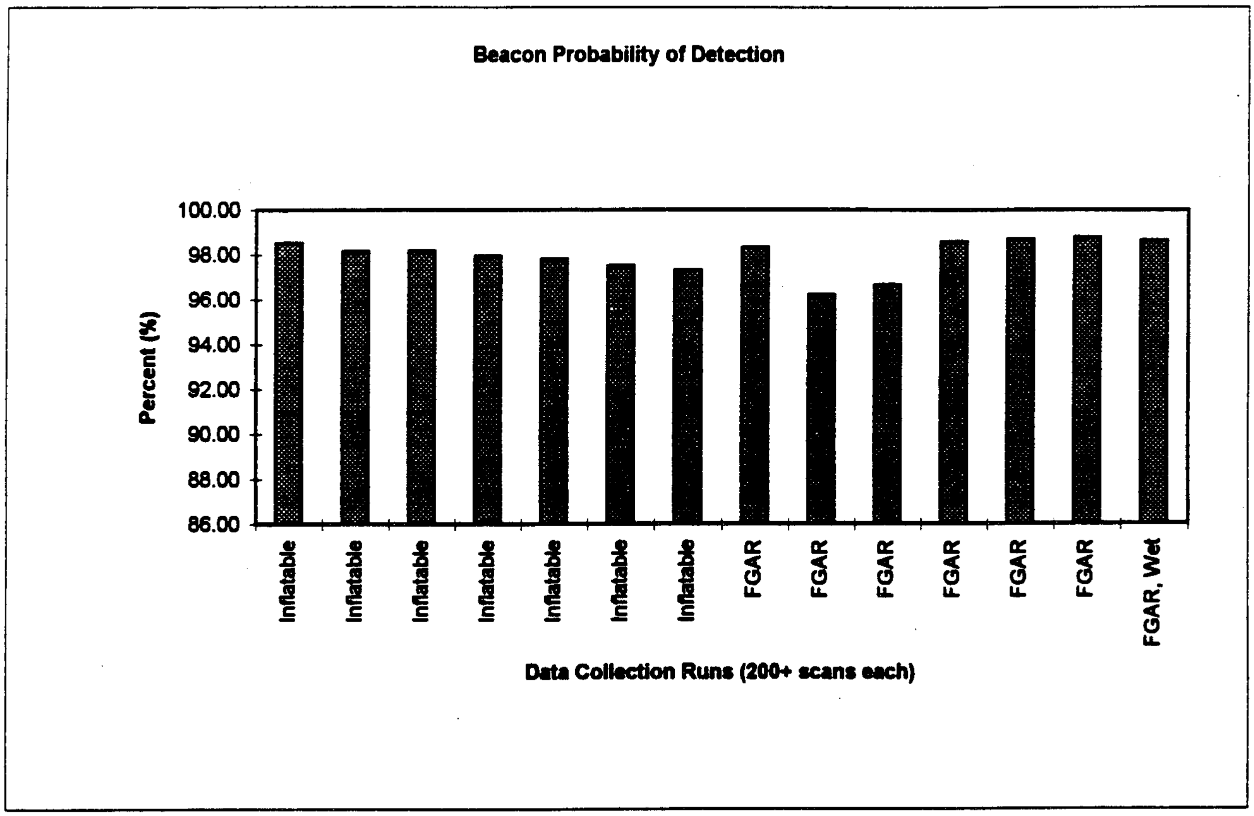

Beacon Probability of Detection
100.00
98.00
96.00
94.00
92.00
90.00
88.00
86.00
Percent (%)
Inflatable
Inflatable
Inflatable
Inflatable
Inflatable
Inflatable
Inflatable
FGAR
FGAR
FGAR
FGAR
FGAR
FGAR
FGAR, Wet
Data Collection Runs (200+ scans each)

FIGURE 25

APPENDIX G

REPORT

ELECTROMAGNETIC PERFORMANCE TESTING WITH RFIM VAN

TRINIDAD EN ROUTE RADAR FACILITY (TAD)

U.S. Department
of Transportation

Federal Aviation Administration

Memorandum

Subject: INFORMATION: Radome Replacement Tests, Trinidad, Colorado

Date: 11/17/94

From: James L. Ulm, ANM-464I

Reply to Attn of: Ulm X2324

To: Manager, ANM-464, Technical Support Section

The attached trip report applies to the Trinidad, Colorado Radome Replacement Project testing, 11 October thru 4 November 1994.

Jim Ulm
Spectrum Management Officer

TRIP REPORT

Date: 10/11/94 thru 11/4/1994

Traveler: Jim Ulm, ANM-464I, Harry Gardner, ANM-464J

Destination: Trinidad, Colorado

Purpose: ARSR Radome Replacement Project Radiated Signal Effects Testing

Background: The ARSR radome replacement, formally known as the fixed ground antenna radome (FGAR), program manager office requested ANM spectrum management office assistance in testing. The objectives of the testing are to verify that the FGAR does not degrade the electromagnetic performance of the enroute radar, Mode-S, or the Air Traffic Control Radar Beacon System (ATCRBS) antenna(s). The ANM-464 spectrum engineers operating the radio frequency interference monitoring (RFIM) van would record the primary and ATCRBS/Mode-S data, using the specialized equipment and programs available in the RFIM van. The data would be reduced and analyzed, and a report generated together with printouts, and raw data sent to the test director.

The difference between the following antenna pattern electromagnetic parameters, when measured before work begins, without a radome and with the FGAR installed, are within the specified limits:

a. Main beam width change (±0.05° max)

b. Boresight error change (0.0085° RMS and .0255° max, vertical and horizontal)

c. Sidelobe level error change (±1 dB, using a sidelobe that is -25 dB from the main lobe of reference)

Activity: On October 11, 1994 Harry Gardner, ANM-464J and I traveled to Trinidad Colorado ARSR and to begin the FGAR testing. Horizontal antenna patterns were taken at the following locations around the ARSR site:

Test Location #1	373329N	1040157W	306.58°	1.08 nm
Test Location #2	373331N	1035918W	60.02°	1.41 nm
Test Location #3	373155N	1040033W	165.39°	.95 nm

Three sets of 360° data were taken for the primary radar, the ATCRB (SLS on), and ATCRB (SLS off) and 3° of main beam data were taken at each location (attachment 1).

We returned on October 25 when the old radome had been removed and took the same measurements as above, with the exception of ATCRB (SLS off) (no omni antenna in place), in addition performed morning and evening vertical antenna measurements (attachment 2).

We returned again on October 31 after the new radome was installed and completed horizontal and vertical antenna measurements (attachment 3).

Conclusions: The following is a list of findings:

1. Main Beam Width Change

	Loc #1	Loc #2	Loc #3	Average
Original	1.60	1.58	1.56	1.58
*No Radome	1.62	1.56	1.51	1.56
New Radome	1.54	1.55	1.56	1.55
Δ Old/New	0.06	0.03	N/C	0.03

The overall difference in 3 dB beam width is 0.03 degrees.

2. Boresight Change

	Loc #1	Loc #2	Loc #3
Original	294.755	53.633	155.941
*No Radome	295.657	53.633	156.392
New Radome	294.755	53.633	155.941
Δ Old/New	N/C	N/C	N/C

There was virtually no change in boresite between the old radome and the new radome in the horizontal plane. Two vertical measurements were made without the radome. Four vertical measurements were made with the new radome in place.

*NOTE: The "No Radome" readings are not considered in the calculations due to wind loading on the antenna sail. The rotation rate varied somewhat with wind speed during the testing with the radome off.

3. Sidelobe Level Change

Due to the rotary joint replacement between the initial measurements with the original radome and measurements with the new radome, the data is invalid. A typical difference between no radome and the new radome sidelobe is included (attachment 4).

Contacts:	Harold Sedgwick	Raytheon Service Co.	(609)641-5544
	Len Baker	ACW-100	(609)485-5353
	Steve Lucero	TAD ARSR	(719)846-9628

Attachments (4)

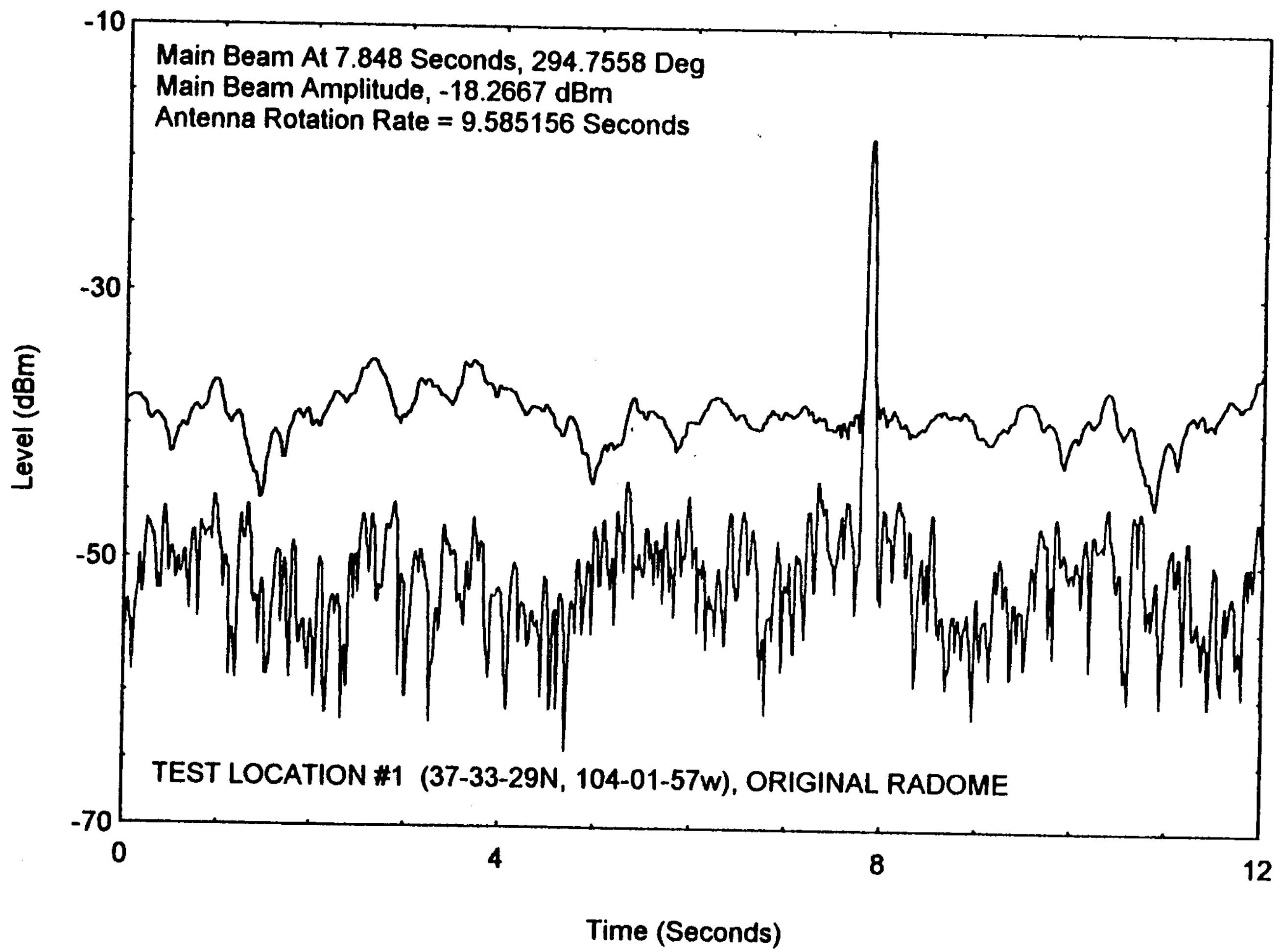
cc: ANM-462
TAD ARSR
ACW-100

ATTACHMENT 1

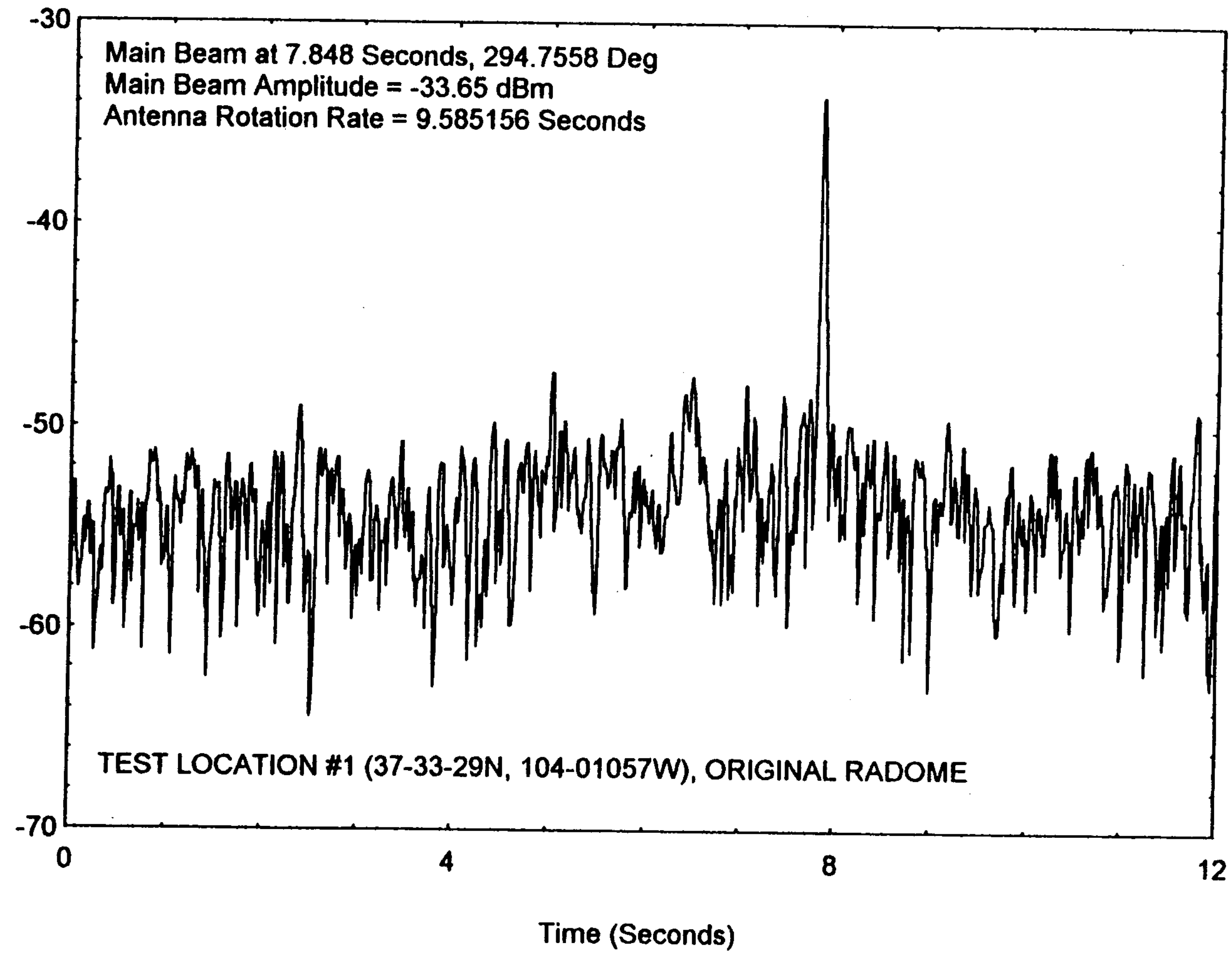
ORIGINAL RADOME

360° Horizontal Plots
Beam Width Plots

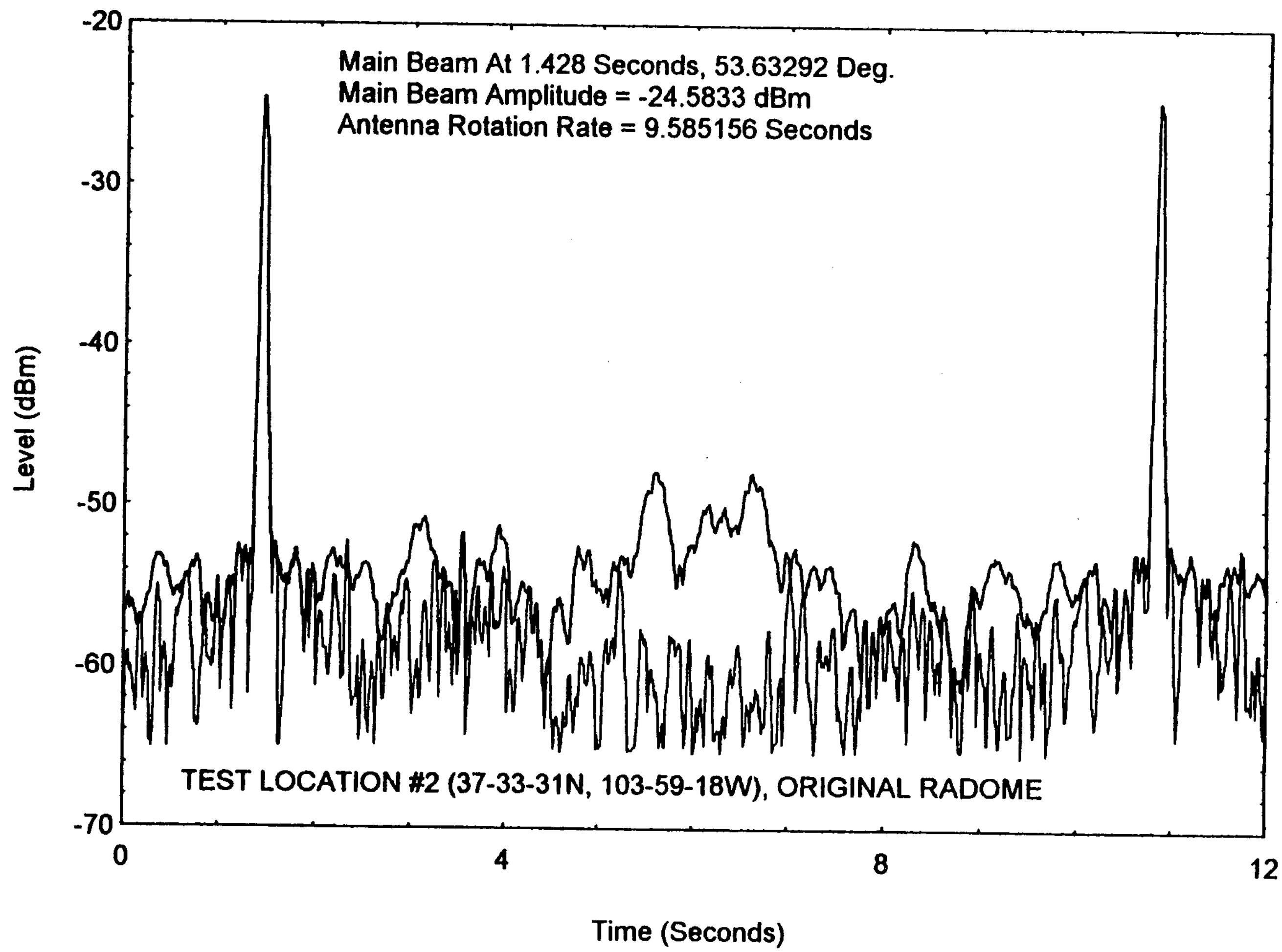
TRINIDAD, CO HORIZONTAL BEACON PLOT

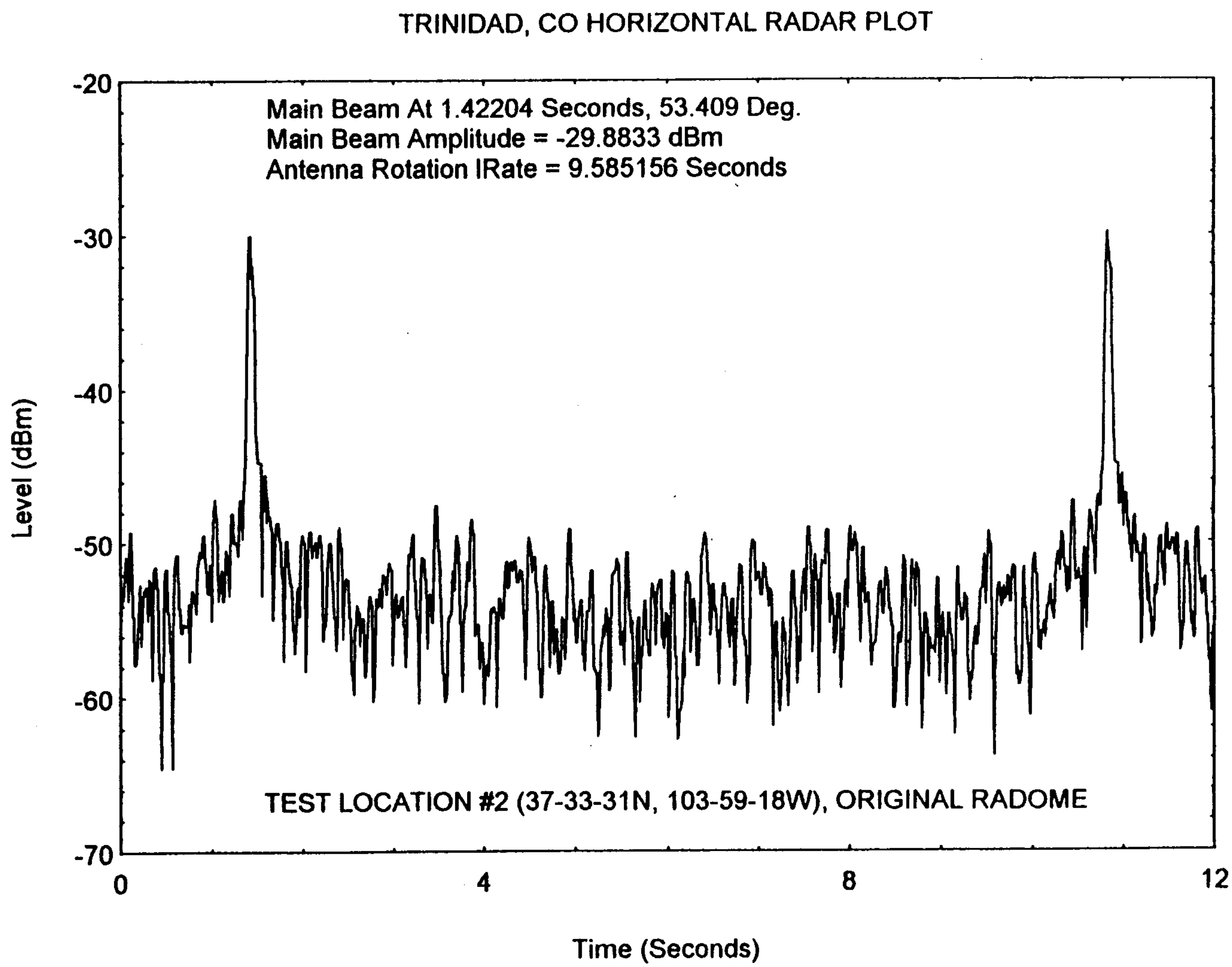


TRINIDAD, CO HORIZONTAL RADAR PLOT

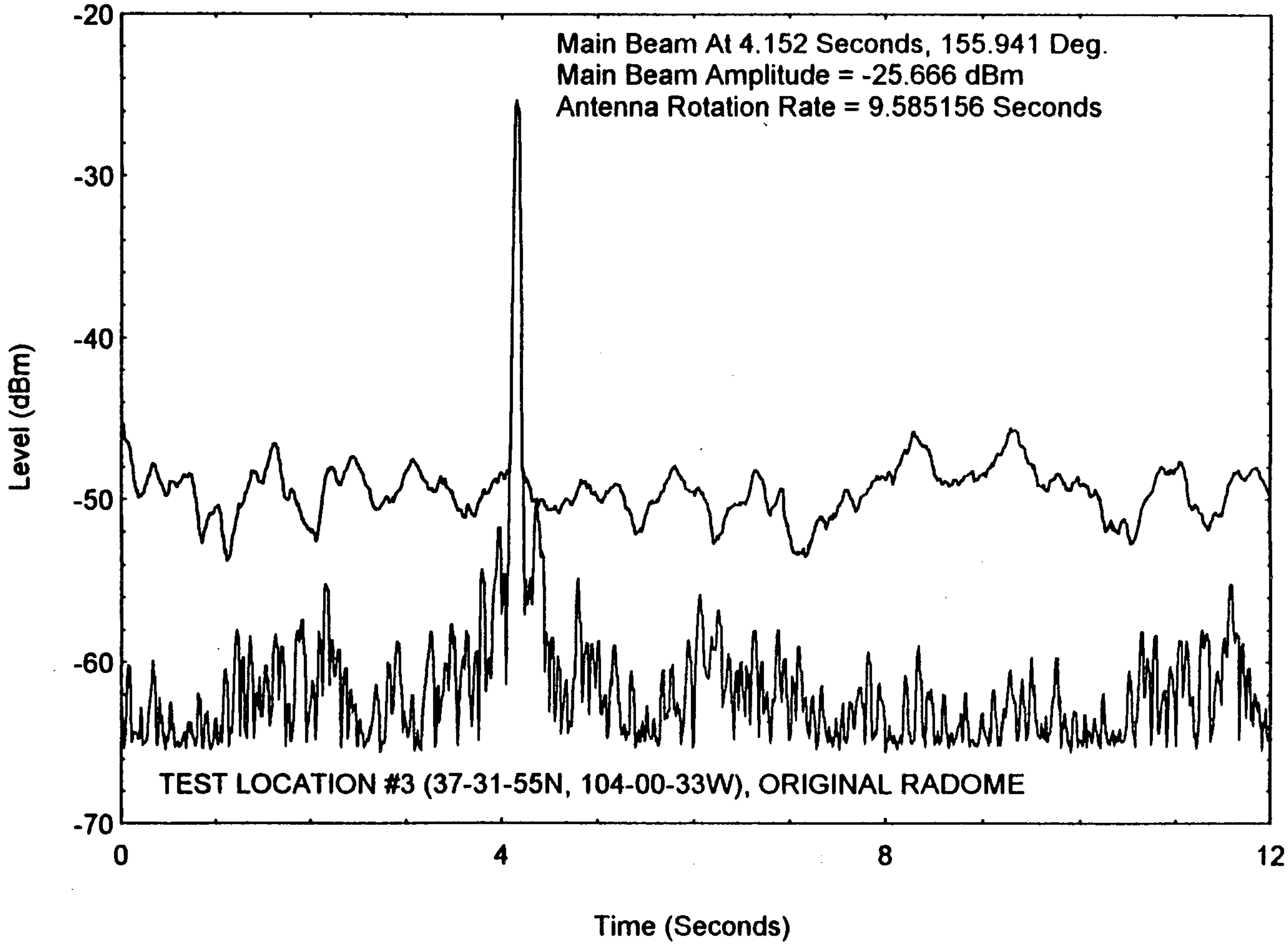


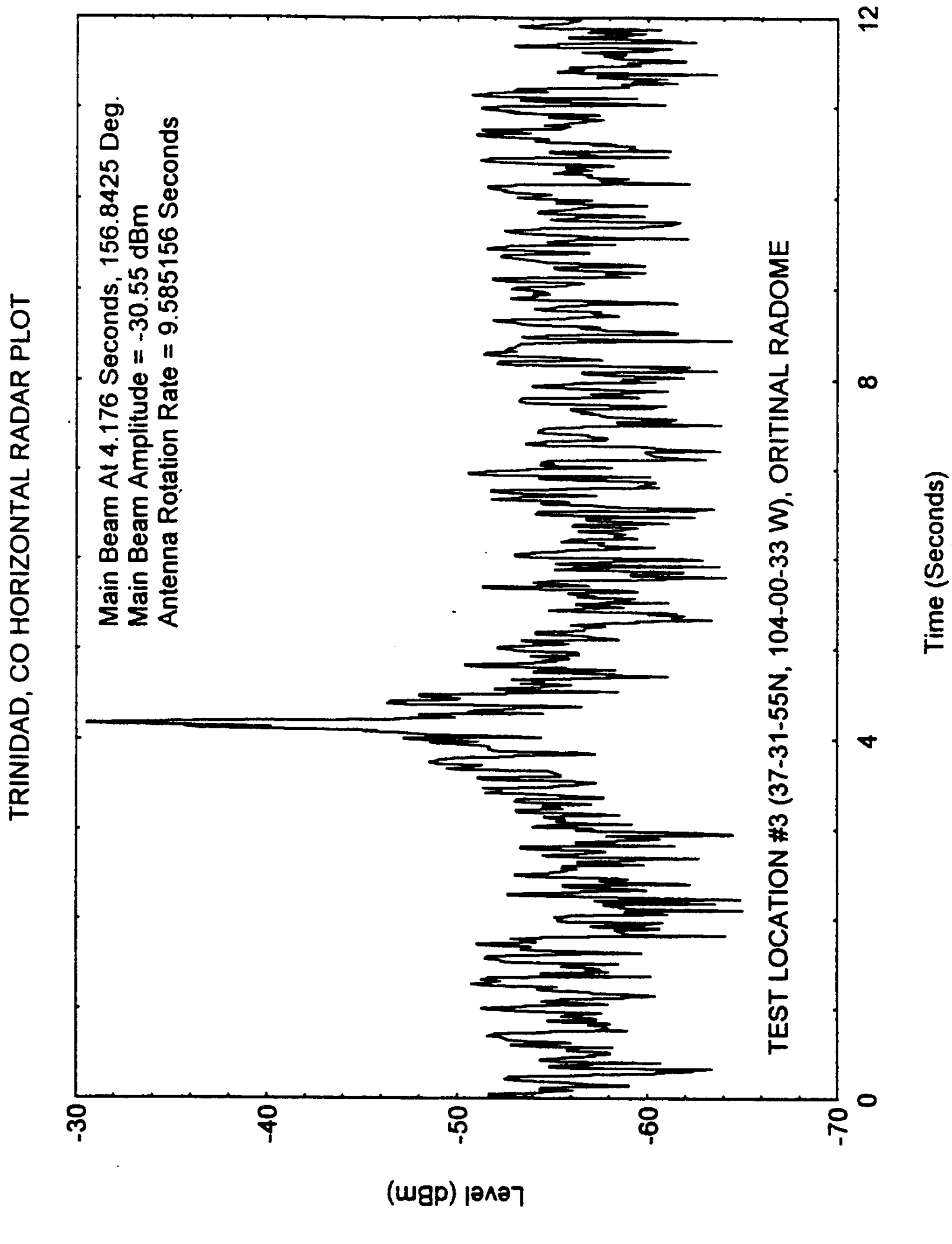
TRINIDAD, CO HORIZONTAL BEACON PLOT

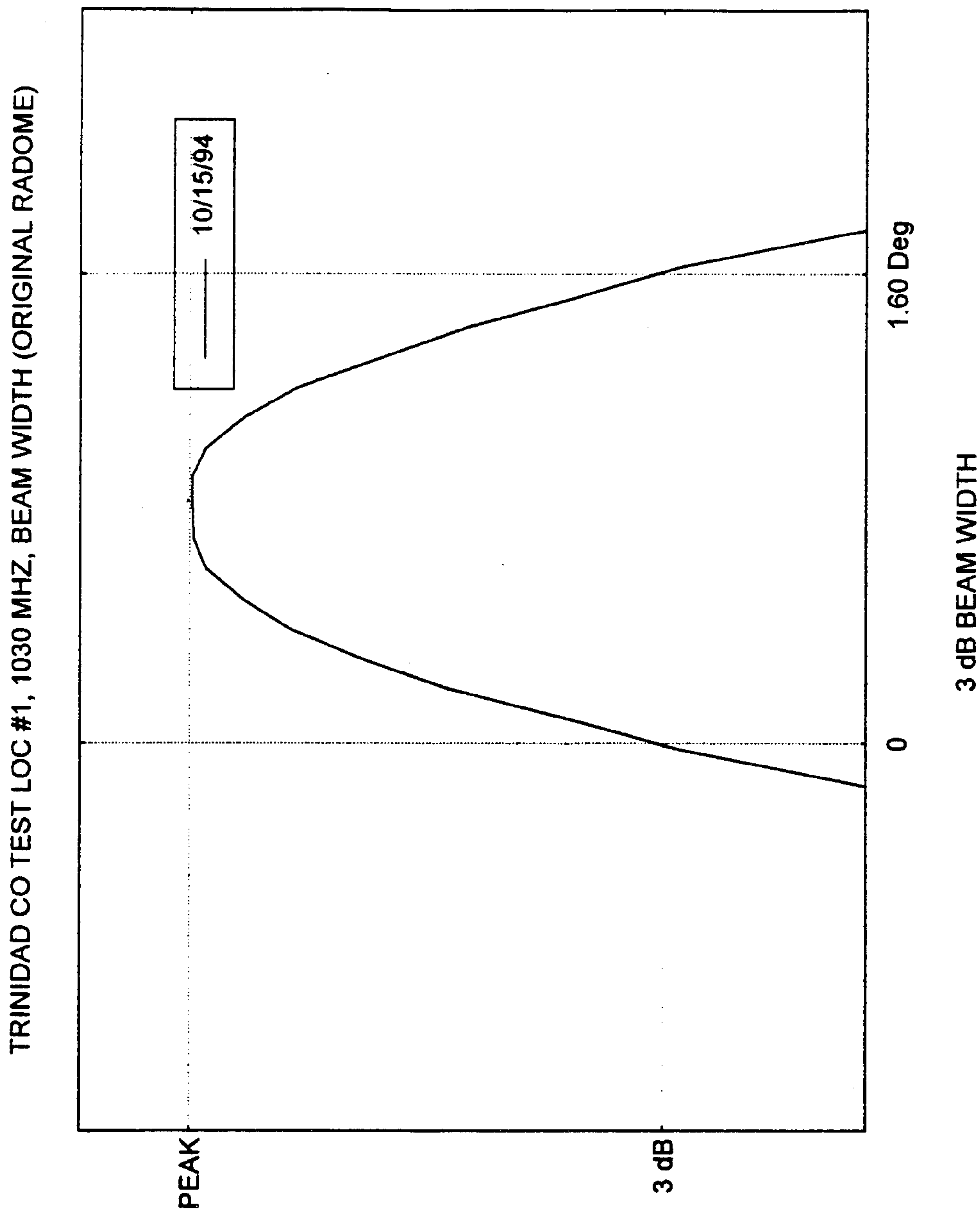


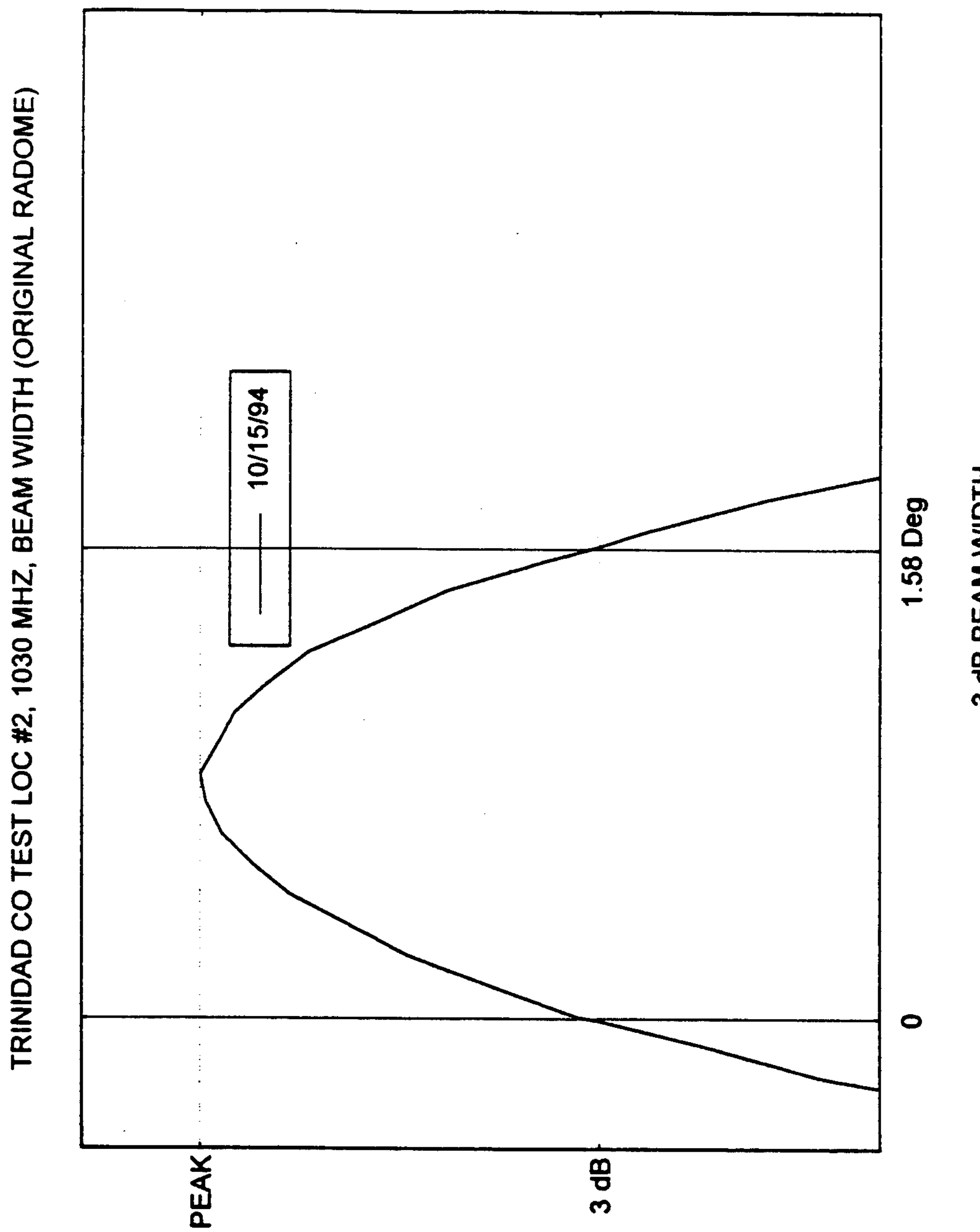

TRINIDAD, CO HORIZONTAL RADAR PLOT
Main Beam At 1.42204 Seconds, 53.409 Deg.
Main Beam Amplitude = -29.8833 dBm
Antenna Rotation IRate = 9.585156 Seconds
TEST LOCATION #2 (37-33-31N, 103-59-18W), ORIGINAL RADOME
Level (dBm)
-20
-30
-40
-50
-60
-70
0
4
8
12
Time (Seconds)

TRINIDAD, CO HORIZONTAL BEACON PLOT




TRINIDAD, CO HORIZONTAL RADAR PLOT
Main Beam At 4.176 Seconds, 156.8425 Deg.
Main Beam Amplitude = -30.55 dBm
Antenna Rotation Rate = 9.585156 Seconds
TEST LOCATION #3 (37-31-55N, 104-00-33 W), ORITINAL RADOME
Level (dBm)
-30
-40
-50
-60
-70
Time (Seconds)
0
4
8
12


TRINIDAD CO TEST LOC #1, 1030 MHZ, BEAM WIDTH (ORIGINAL RADOME)
10/15/94
PEAK
3 dB
0
1.60 Deg
3 dB BEAM WIDTH

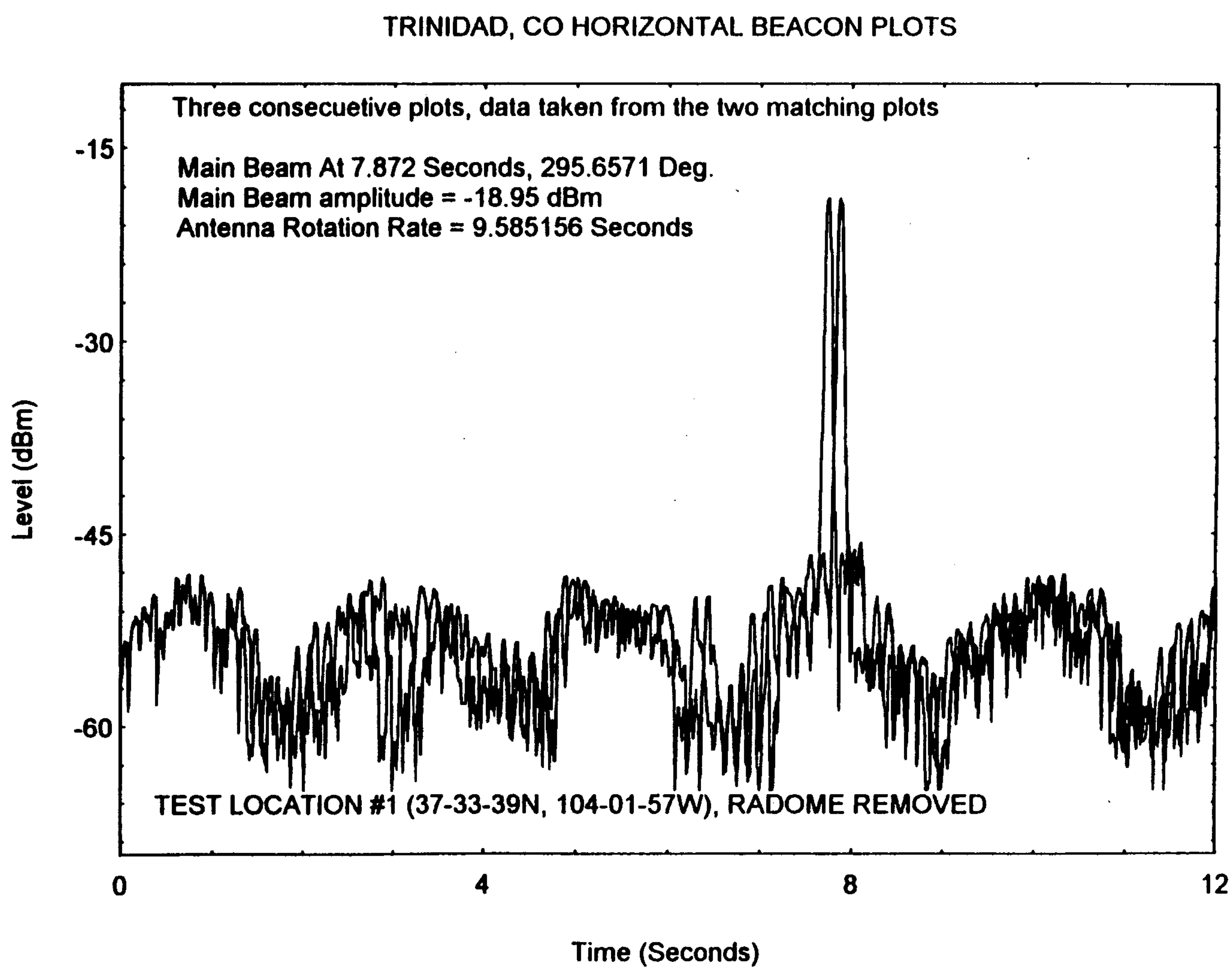


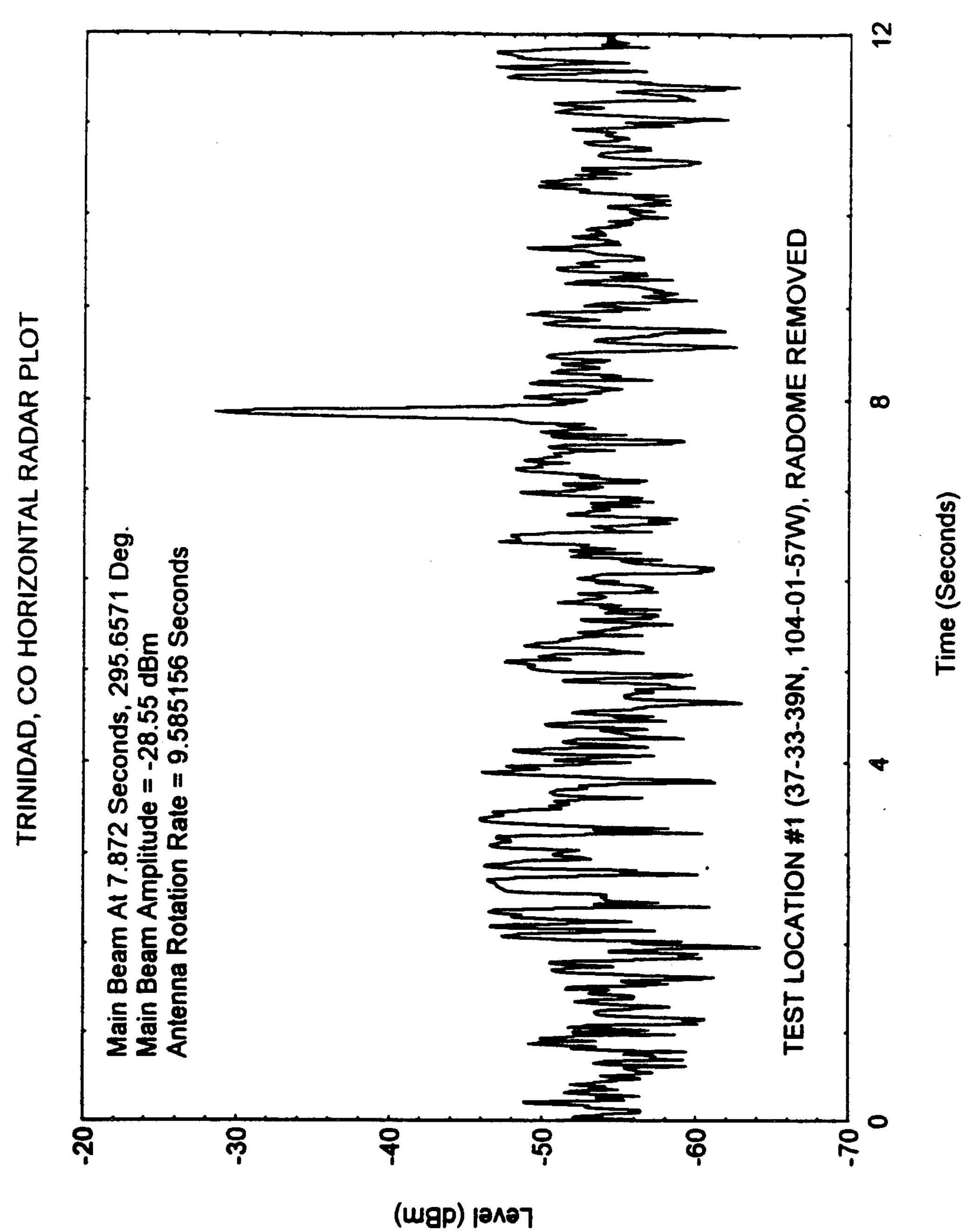
TRINIDAD CO TEST LOC #2, 1030 MHZ, BEAM WIDTH (ORIGINAL RADOME)
10/15/94
PEAK
3 dB
0
1.58 Deg
3 dB BEAM WIDTH

ATTACHMENT 2

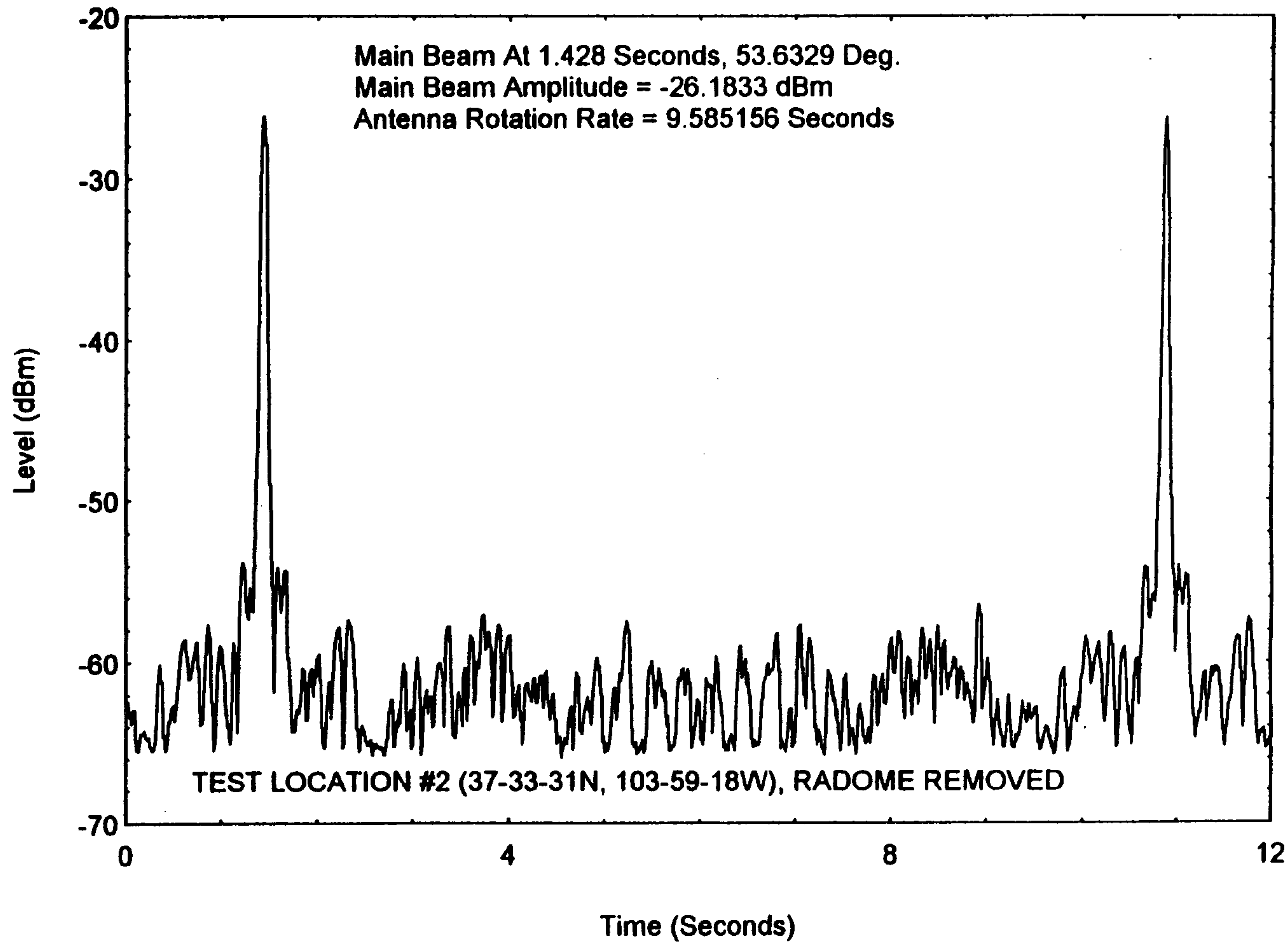
RADOME REMOVED

360° Horizontal Plots
Beam Width Plots
Vertical Plots (Solars)

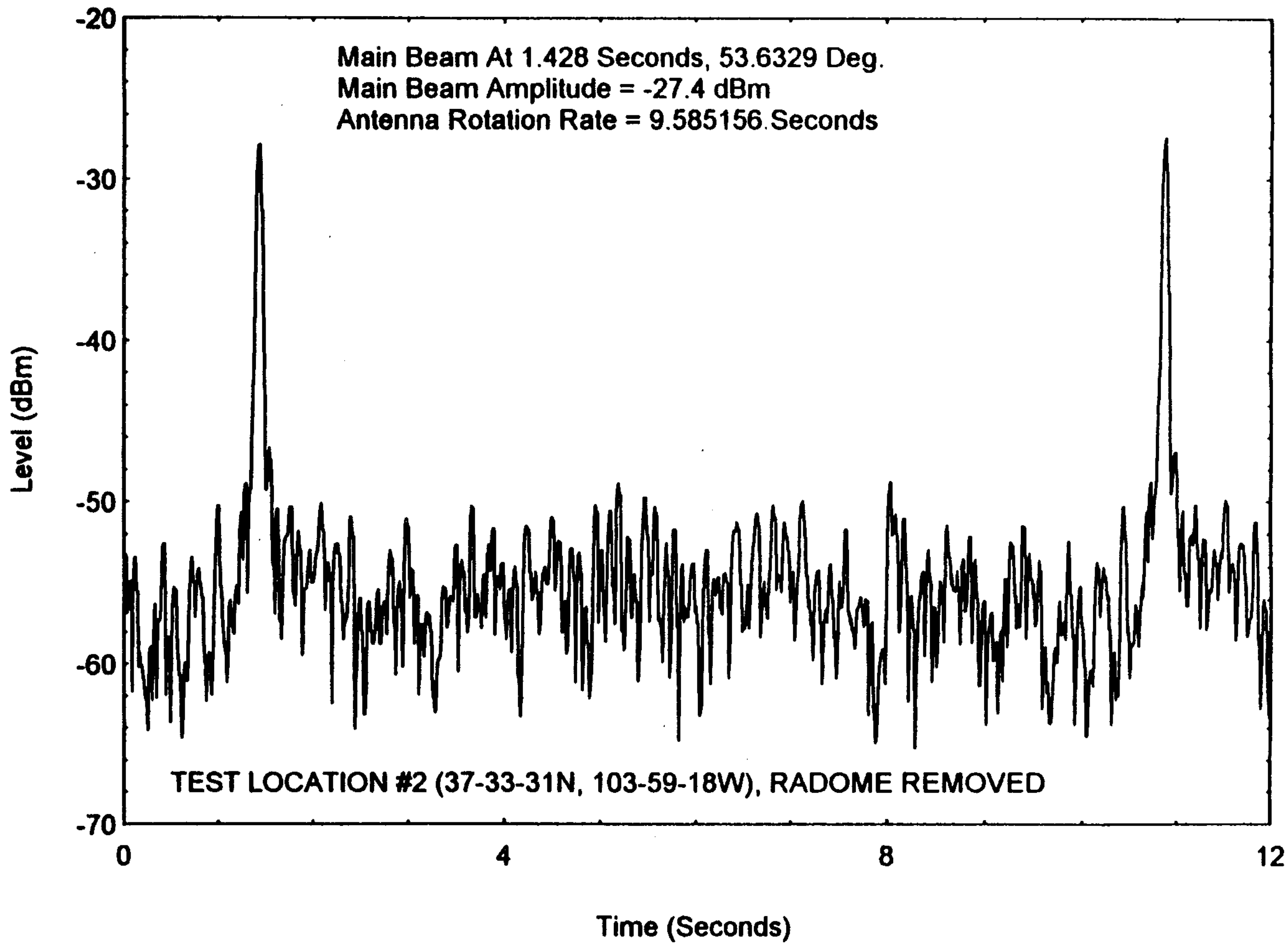

TRINIDAD, CO HORIZONTAL BEACON PLOTS
Three consecuetive plots, data taken from the two matching plots
Main Beam At 7.872 Seconds, 295.6571 Deg.
Main Beam amplitude = -18.95 dBm
Antenna Rotation Rate = 9.585156 Seconds
TEST LOCATION #1 (37-33-39N, 104-01-57W), RADOME REMOVED
-15
-30
-45
-60
Level (dBm)
0
4
8
12
Time (Seconds)

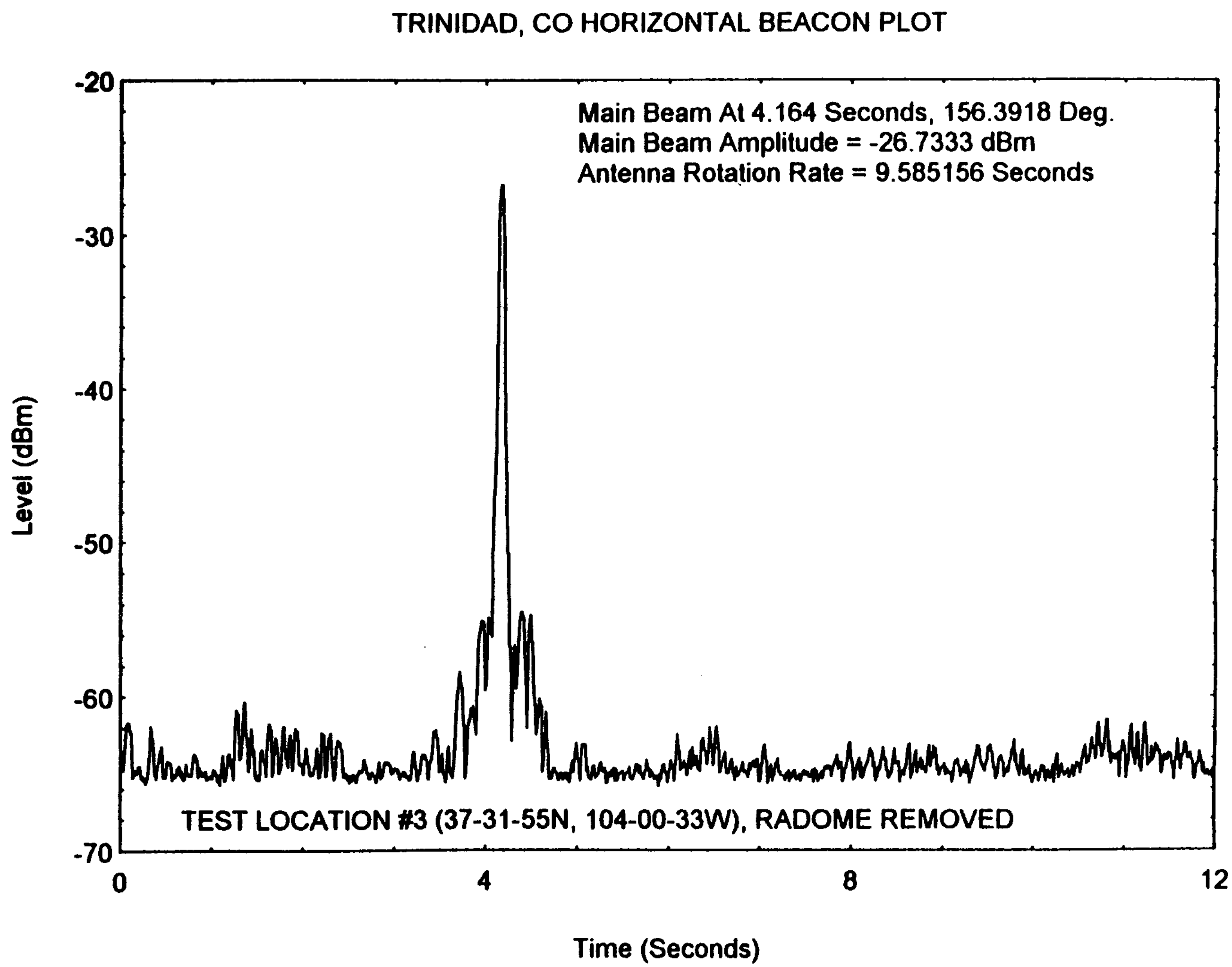

TRINIDAD, CO HORIZONTAL RADAR PLOT
Main Beam At 7.872 Seconds, 295.6571 Deg.
Main Beam Amplitude = -28.55 dBm
Antenna Rotation Rate = 9.585156 Seconds
TEST LOCATION #1 (37-33-39N, 104-01-57W), RADOME REMOVED
Level (dBm)
-20
-30
-40
-50
-60
-70
0
4
8
12
Time (Seconds)

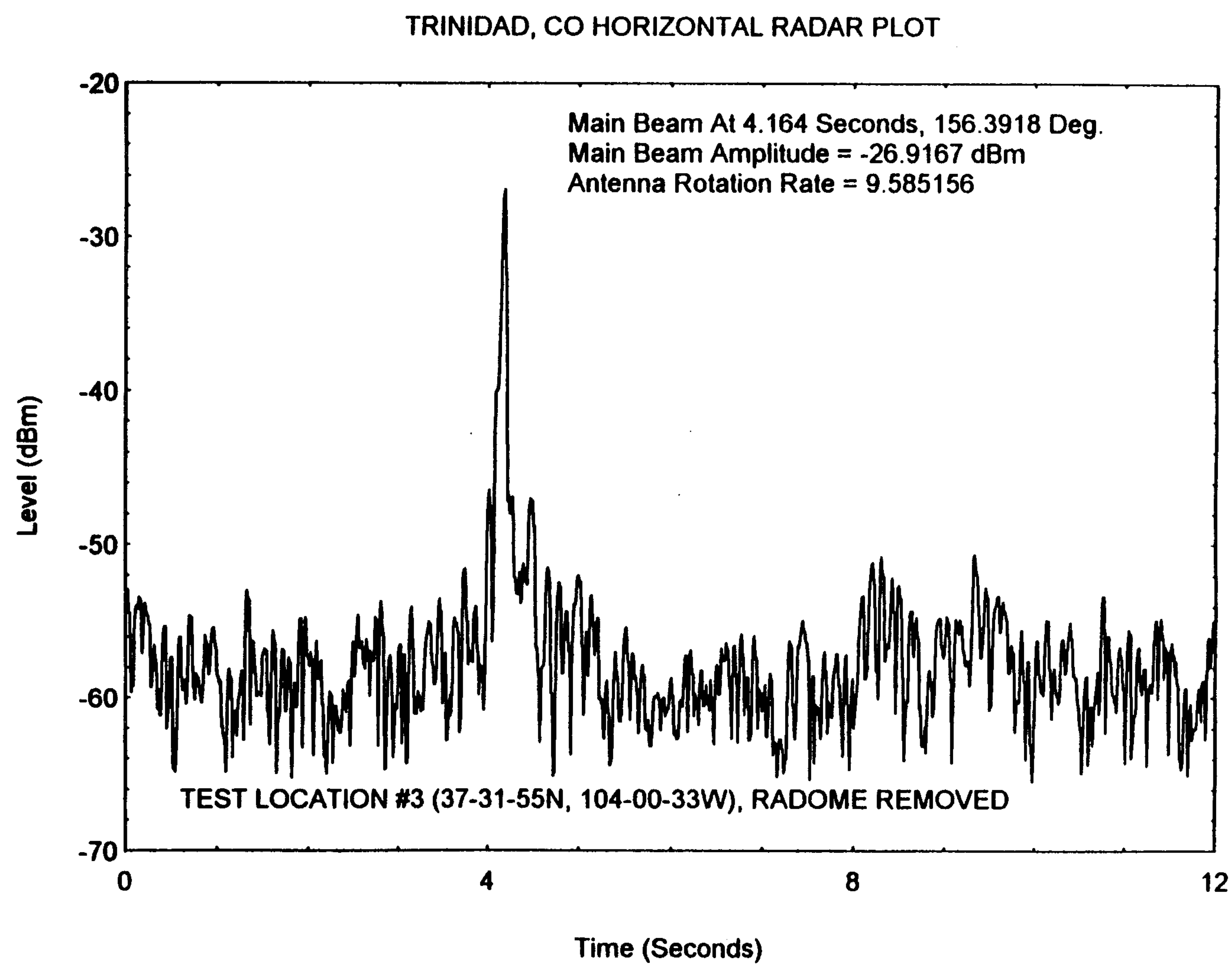
TRINIDAD, CO HORIZONTAL BEACON PLOT



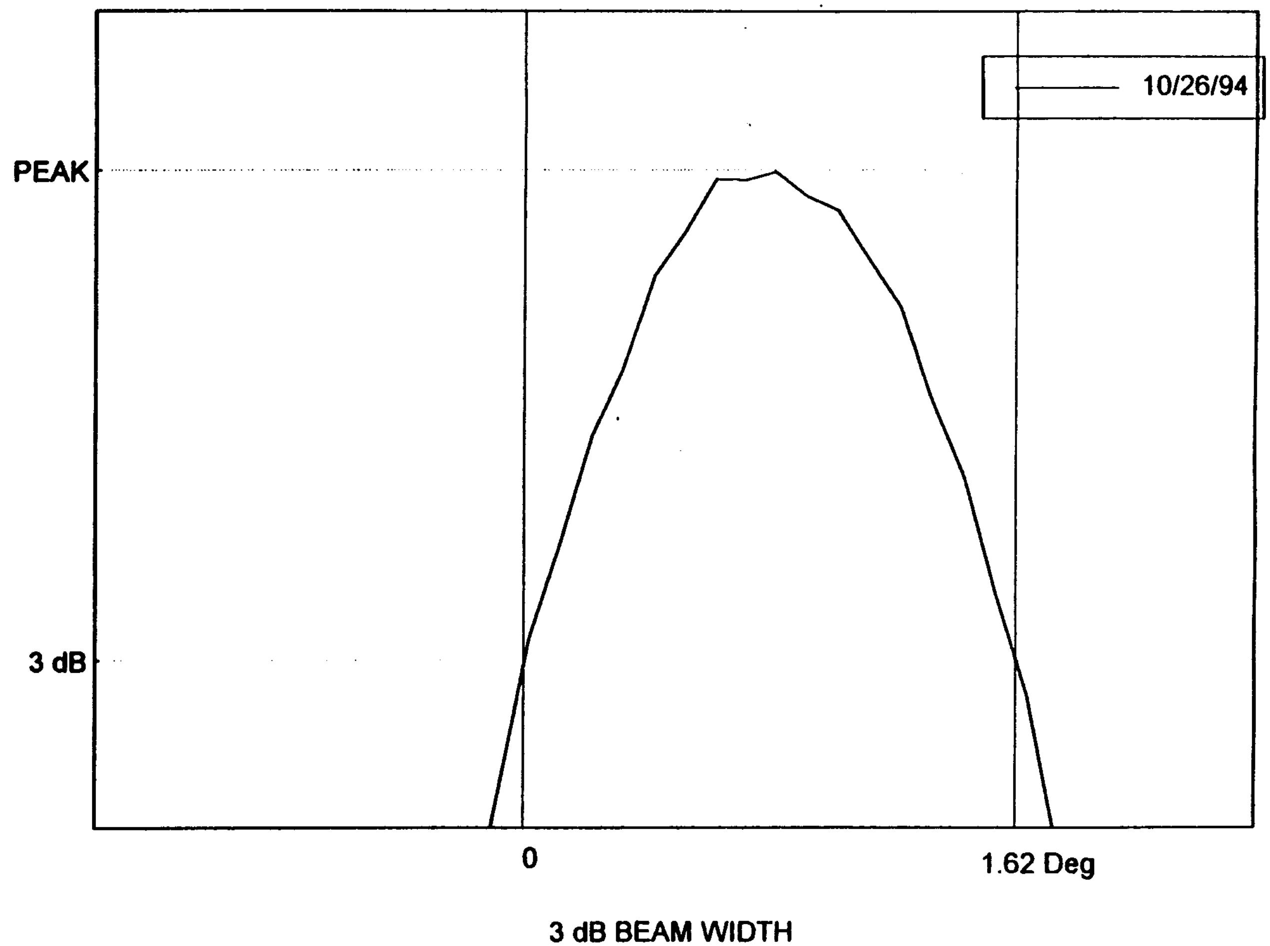
TRINIDAD, CO HORIZONTAL RADAR PLOT

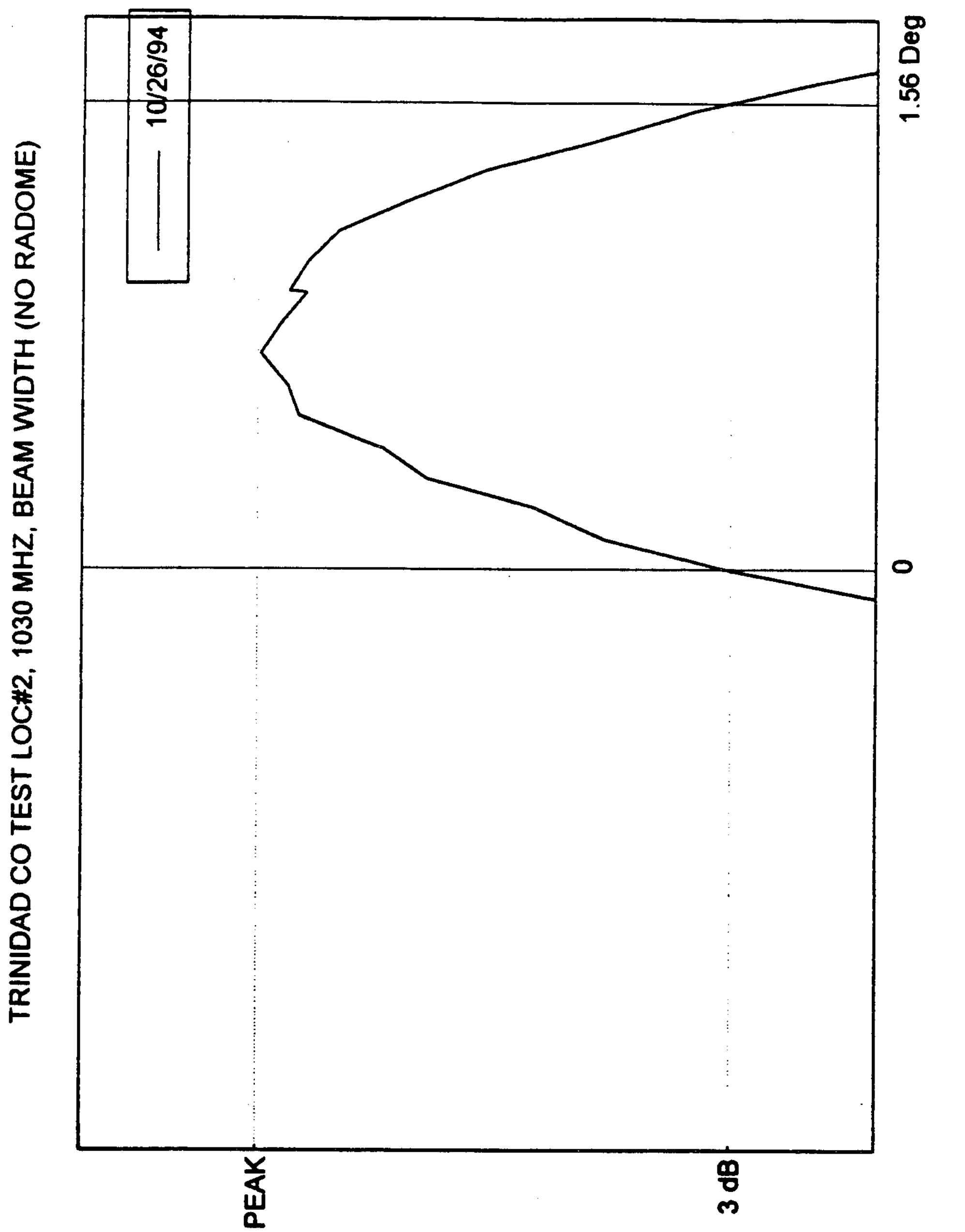



TRINIDAD, CO HORIZONTAL BEACON PLOT
Main Beam At 4.164 Seconds, 156.3918 Deg.
Main Beam Amplitude = -26.7333 dBm
Antenna Rotation Rate = 9.585156 Seconds
TEST LOCATION #3 (37-31-55N, 104-00-33W), RADOME REMOVED
Level (dBm)
-20
-30
-40
-50
-60
-70
0
4
8
12
Time (Seconds)

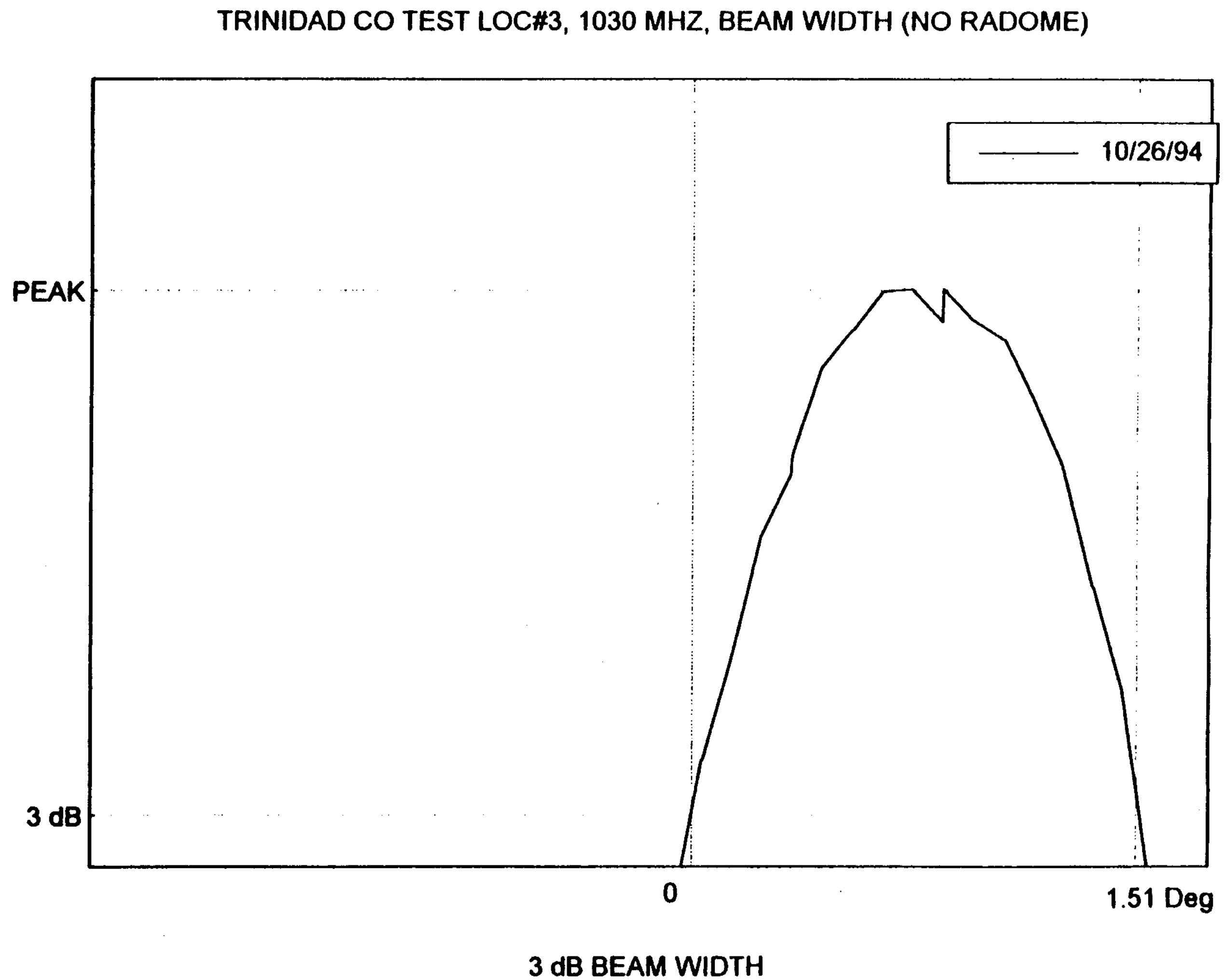

TRINIDAD, CO HORIZONTAL RADAR PLOT
Main Beam At 4.164 Seconds, 156.3918 Deg.
Main Beam Amplitude = -26.9167 dBm
Antenna Rotation Rate = 9.585156
TEST LOCATION #3 (37-31-55N, 104-00-33W), RADOME REMOVED
Level (dBm)
-20
-30
-40
-50
-60
-70
0
4
8
12
Time (Seconds)

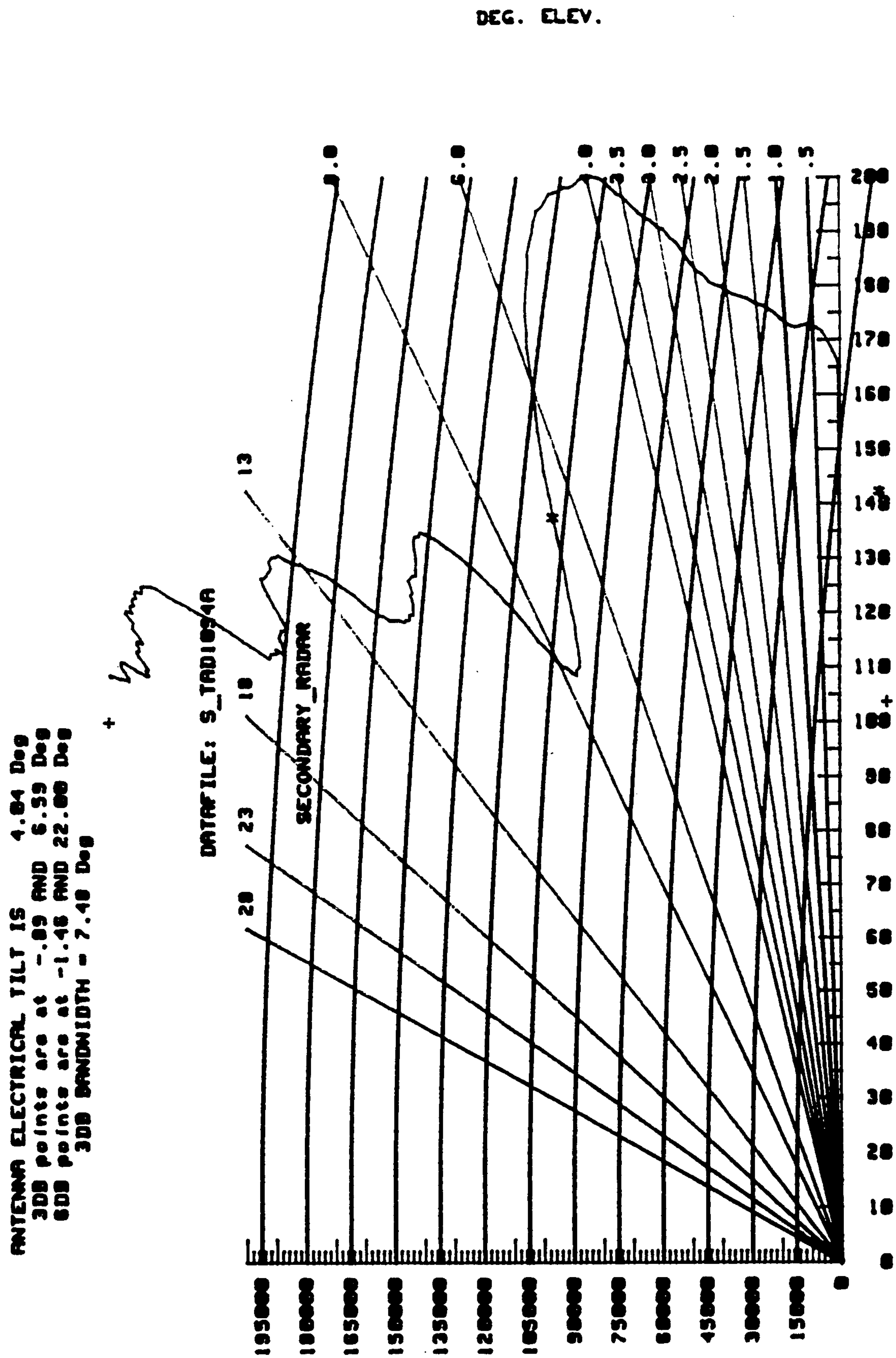
TRINIDAD CO TEST LOC#1, 1030 MHZ, BEAM WIDTH (NO RADOME)





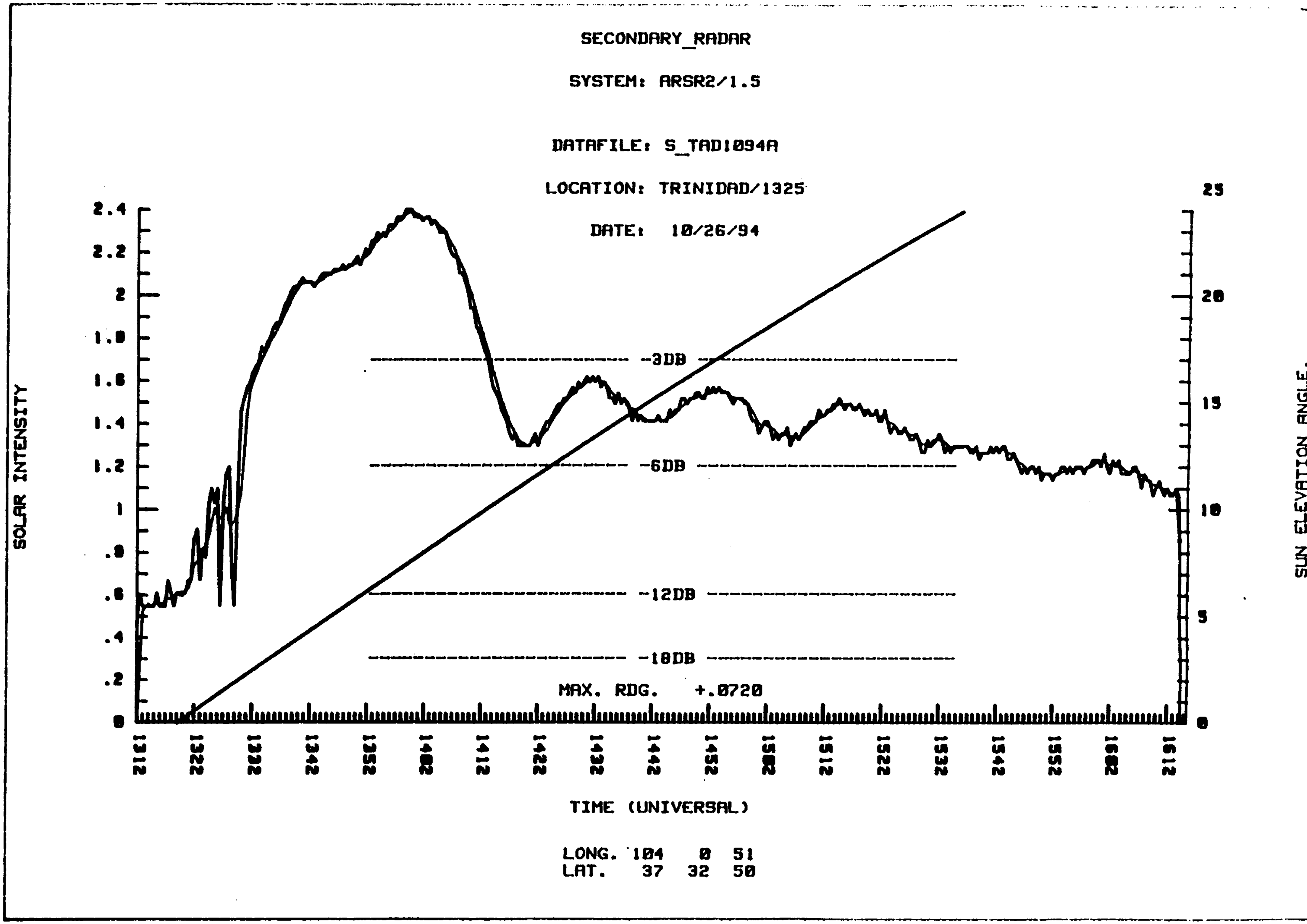
TRINIDAD CO TEST LOC#2, 1030 MHZ, BEAM WIDTH (NO RADOME)
10/26/94
PEAK
3 dB
0
1.56 Deg
3 dB BEAM WIDTH


TRINIDAD CO TEST LOC#3, 1030 MHZ, BEAM WIDTH (NO RADOME)
10/26/94
PEAK
3 dB
0
1.51 Deg
3 dB BEAM WIDTH



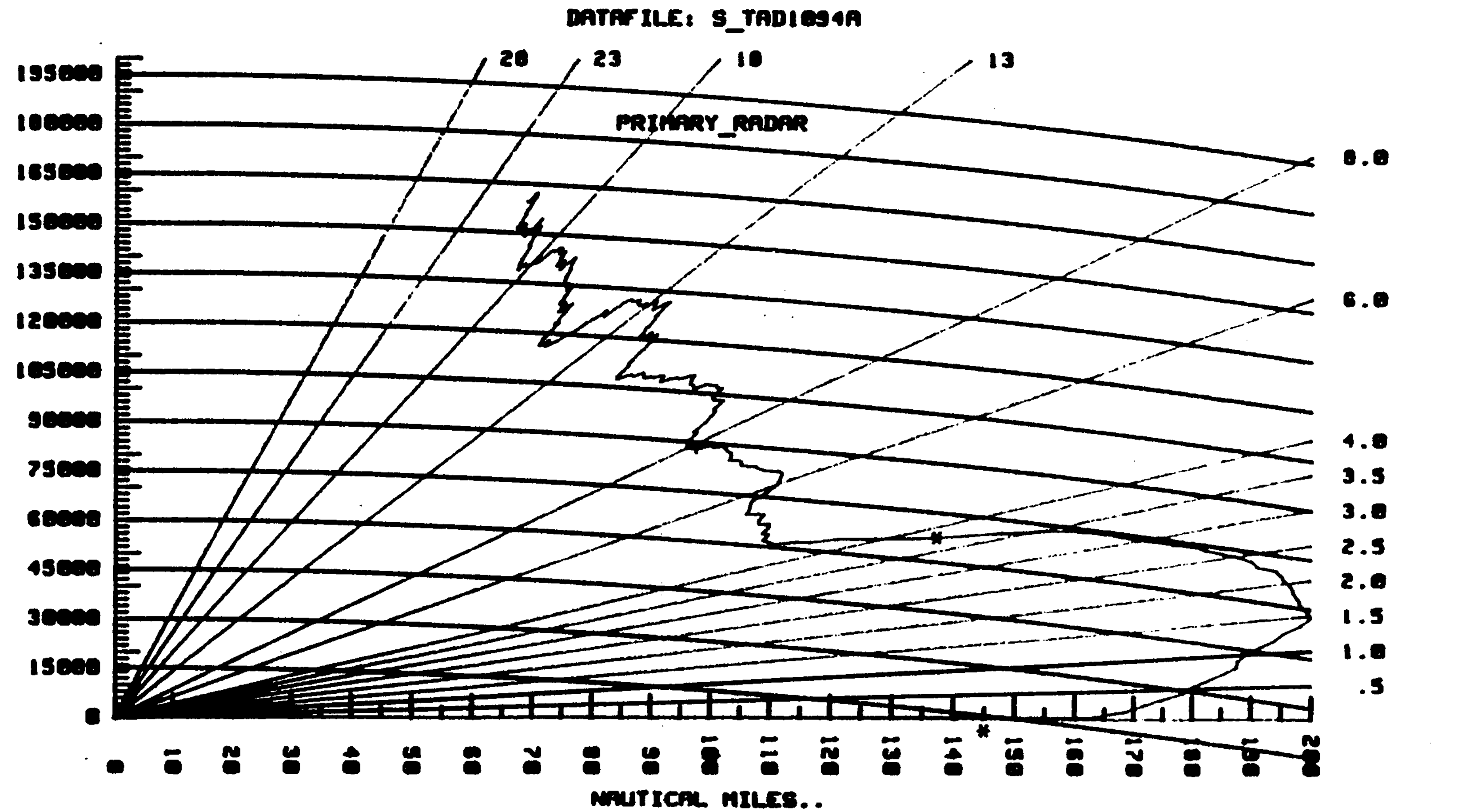
EVALUATE TILT AT 1.5

LOCATION TRINIDAD/1325


SECONDARY_RADAR
SYSTEM: ARSR2/1.5
DATAFILE: S_TAD1094A
LOCATION: TRINIDAD/1325
DATE: 10/26/94
SOLAR INTENSITY
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
SUN ELEVATION ANGLE.
25
20
15
10
5
0
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0720
1312
1322
1332
1342
1352
1402
1412
1422
1432
1442
1452
1502
1512
1522
1532
1542
1552
1602
1612
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50

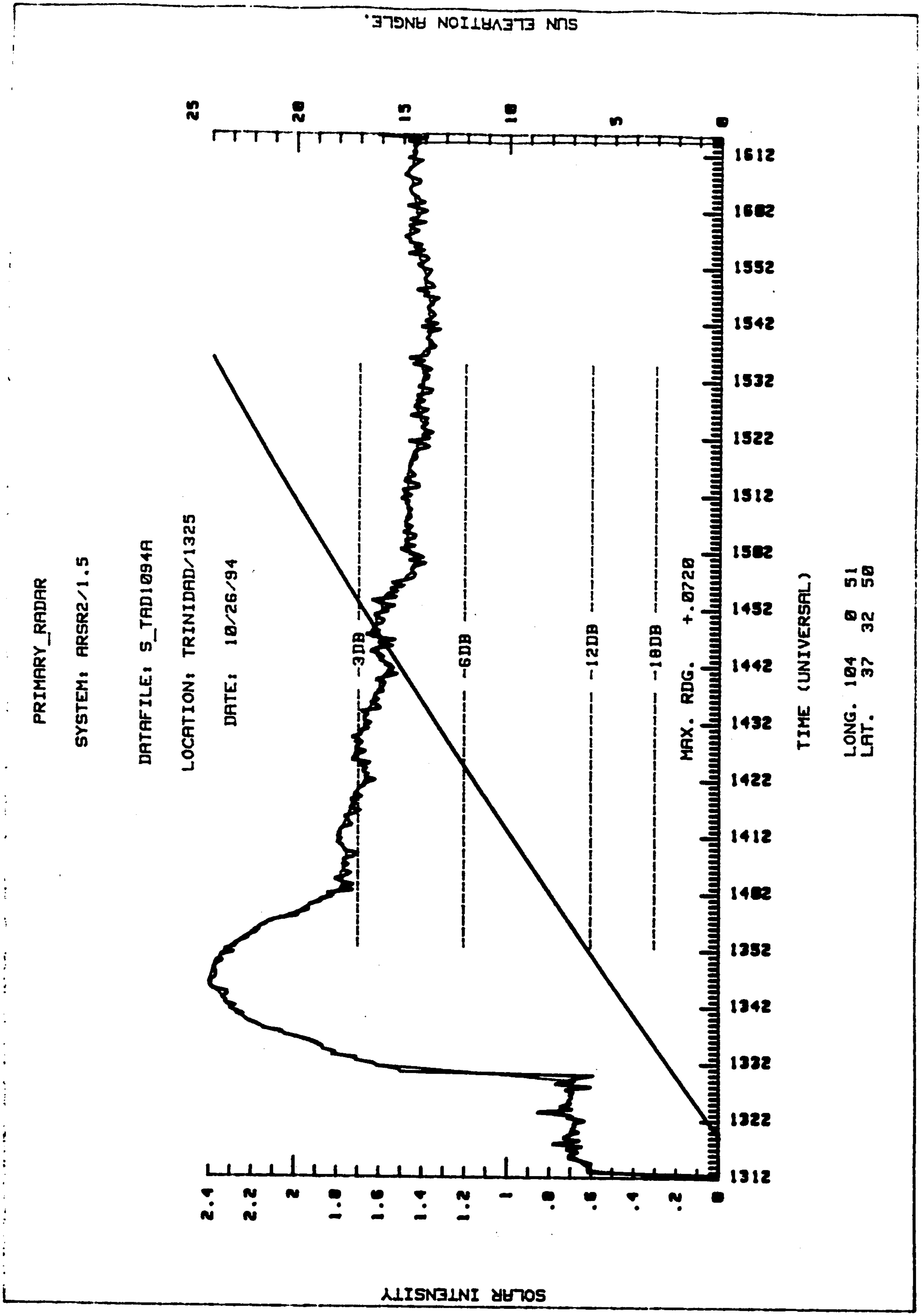
72MV

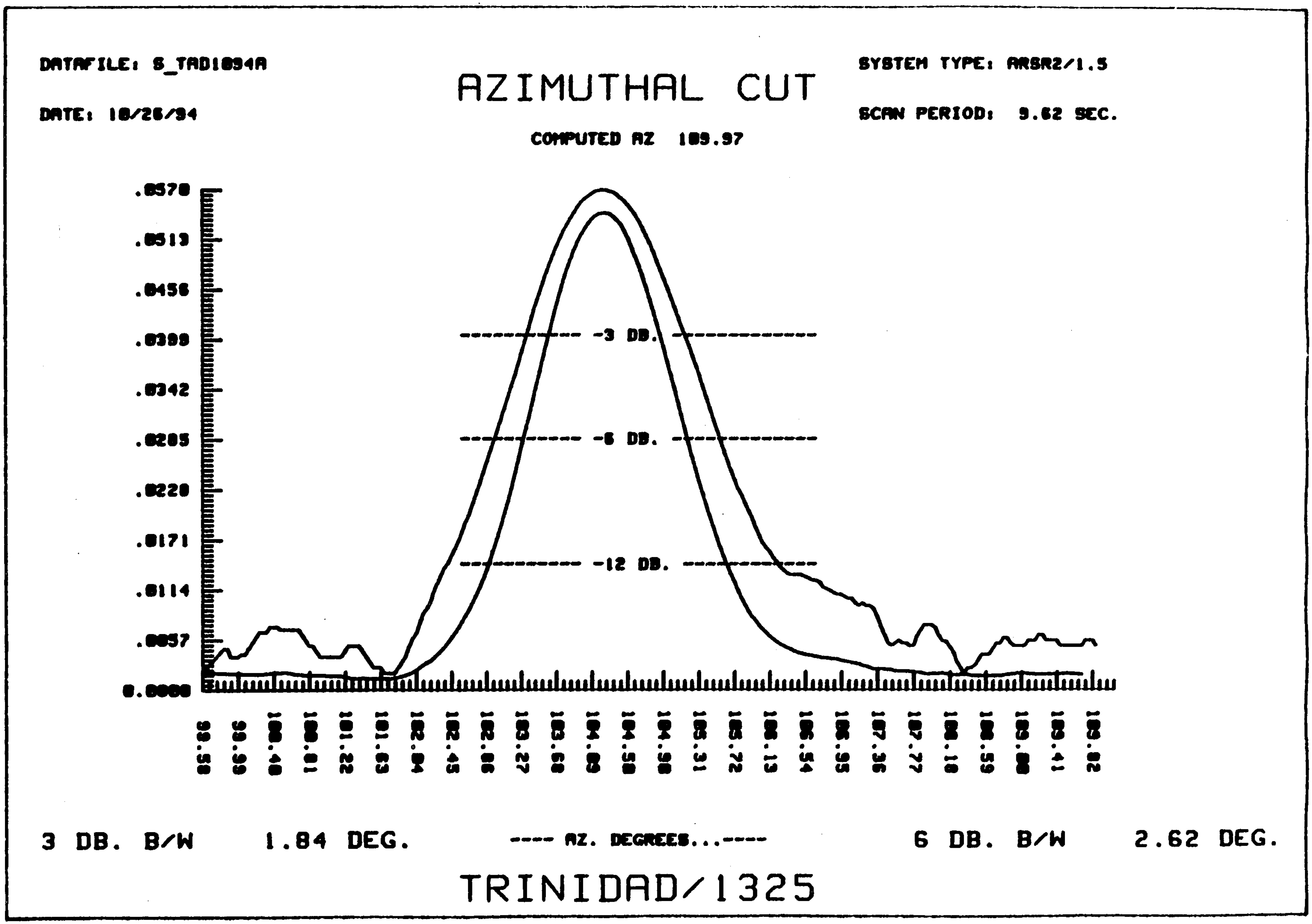
ANTENNA ELECTRICAL TILT IS 1.45 Deg
3DB points are at -.23 AND 3.76 Deg
6DB points are at -1.00 AND 7.04 Deg
3DB BANDWIDTH = 4.00 Deg

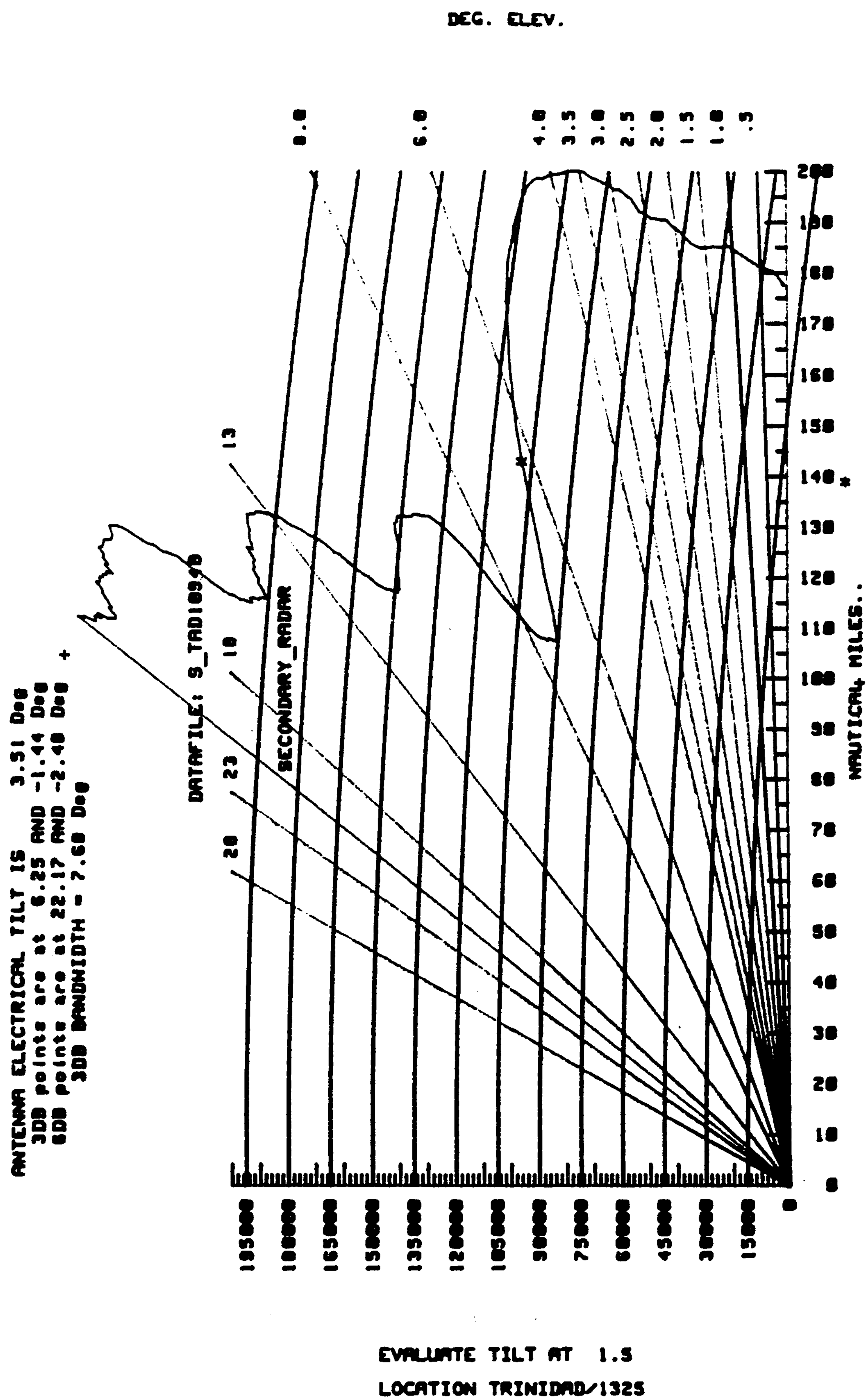


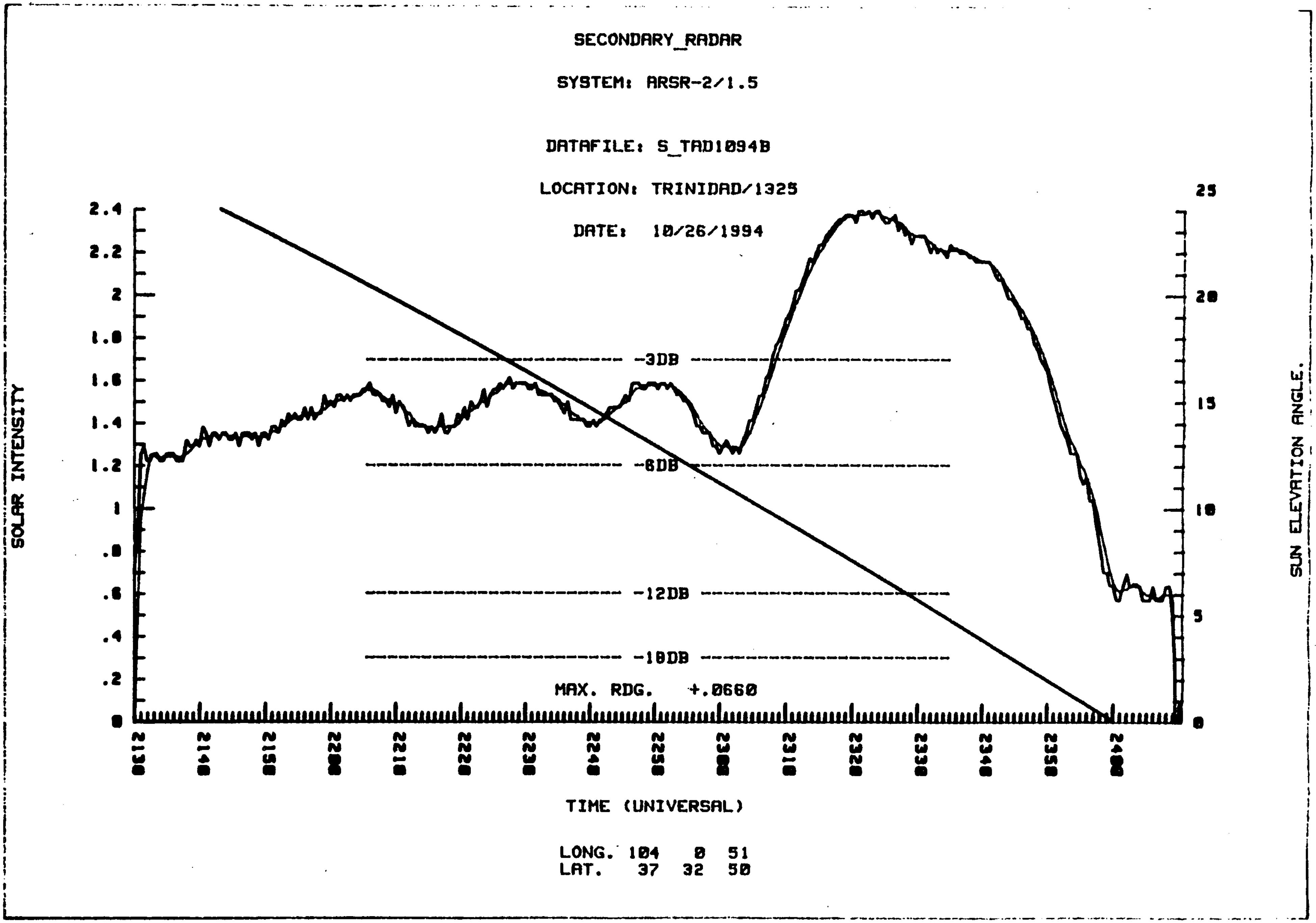
EVALUATE TILT AT 1.5

LOCATION TRINIDAD/1325

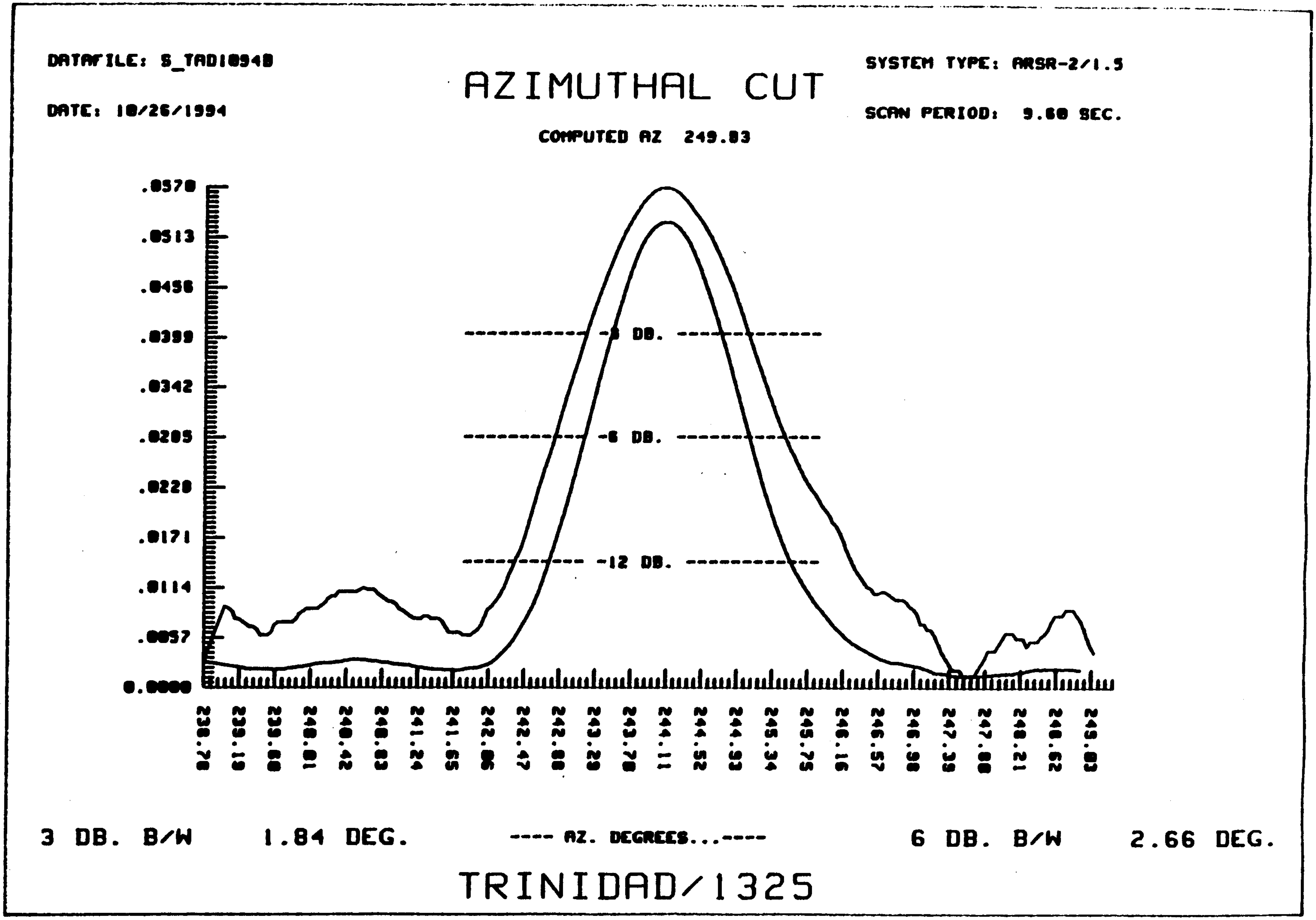

PRIMARY_RADAR
SYSTEM: ARSR2/1.5
DATAFILE: S_TAD1094A
LOCATION: TRINIDAD/1325
DATE: 10/26/94
SUN ELEVATION ANGLE.
25
20
15
10
5
0
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0720
1312
1322
1332
1342
1352
1402
1412
1422
1432
1442
1452
1502
1512
1522
1532
1542
1552
1602
1612
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
SOLAR INTENSITY


DATAFILE: S_TAD1094A
DATE: 10/26/94
AZIMUTHAL CUT
COMPUTED AZ 103.97
SYSTEM TYPE: ARSR2/1.5
SCAN PERIOD: 9.62 SEC.
.0570
.0513
.0456
.0399
.0342
.0285
.0228
.0171
.0114
.0057
0.0000
-3 DB.
-6 DB.
-12 DB.
99.58
99.99
100.40
100.81
101.22
101.63
102.04
102.45
102.86
103.27
103.68
104.09
104.50
104.90
105.31
105.72
106.13
106.54
106.95
107.36
107.77
108.18
108.59
109.00
109.41
109.82
3 DB. B/W 1.84 DEG.
---- AZ. DEGREES...----
6 DB. B/W 2.62 DEG.
TRINIDAD/1325

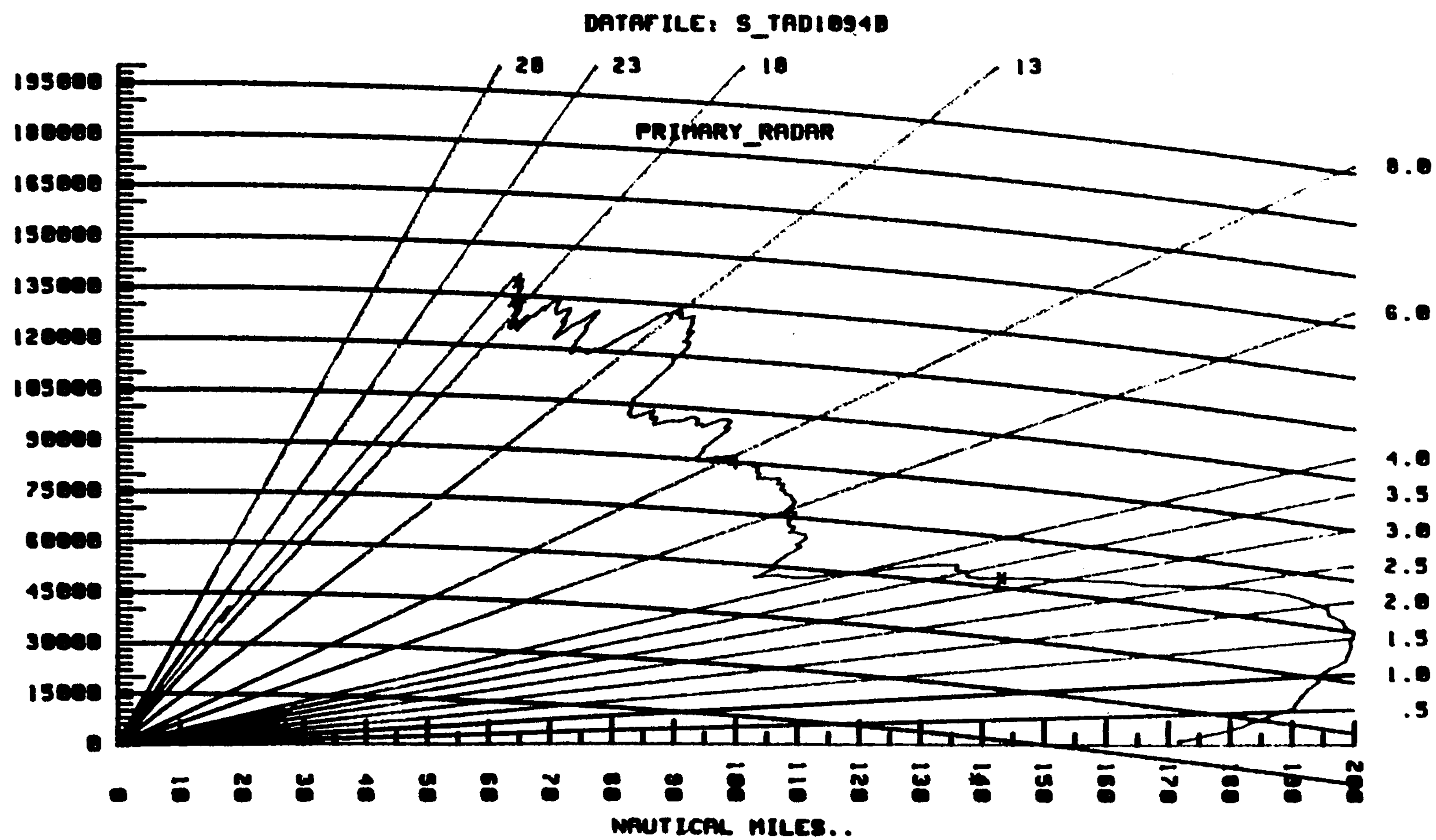

DEG. ELEV.
8.0
6.0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
ANTENNA ELECTRICAL TILT IS 3.51 Deg
3DB points are at 6.25 AND -1.44 Deg
6DB points are at 22.17 AND -2.40 Deg +
3DB BANDWIDTH = 7.68 Deg
DATAFILE: S_TADI0948
SECONDARY_RADAR
13
10
23
20
195000
180000
165000
150000
135000
120000
105000
90000
75000
60000
45000
30000
15000
0
200
190
180
170
160
150
140 *
130
120
110
100
90
80
70
60
50
40
30
20
10
0
NAUTICAL MILES..
EVALUATE TILT AT 1.5
LOCATION TRINIDAD/1325



SECONDARY_RADAR
SYSTEM: ARSR-2/1.5
DATAFILE: S_TAD1094B
LOCATION: TRINIDAD/1325
DATE: 10/26/1994
SOLAR INTENSITY
SUN ELEVATION ANGLE.
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0660
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50

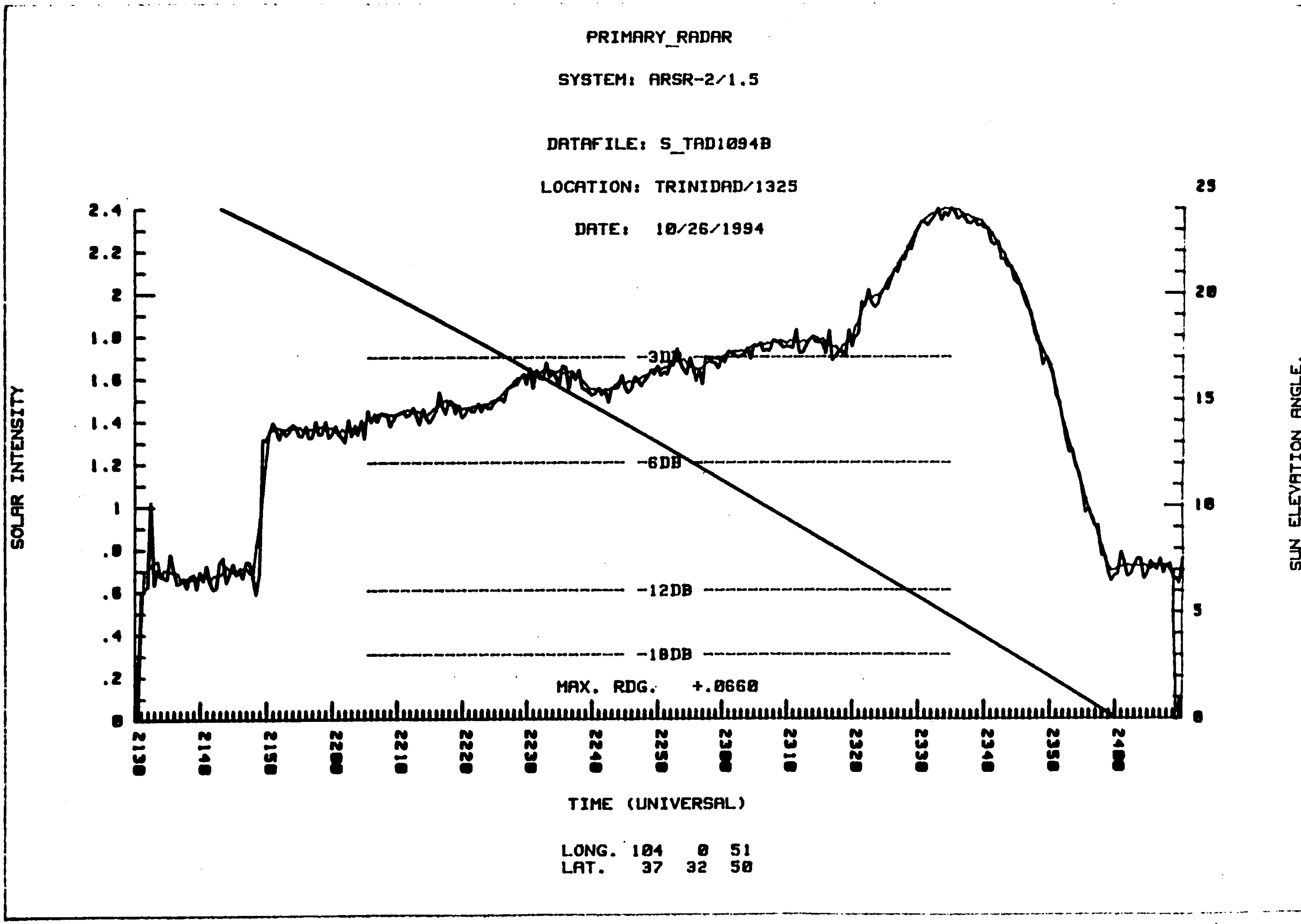

DATAFILE: S_TAD10940
DATE: 10/26/1994
AZIMUTHAL CUT
COMPUTED AZ 249.03
SYSTEM TYPE: ARSR-2/1.5
SCAN PERIOD: 9.60 SEC.
.0570
.0513
.0456
.0399
.0342
.0285
.0228
.0171
.0114
.0057
0.0000
-3 DB.
-6 DB.
-12 DB.
238.78
239.19
239.60
240.01
240.42
240.83
241.24
241.65
242.06
242.47
242.88
243.29
243.70
244.11
244.52
244.93
245.34
245.75
246.16
246.57
246.98
247.39
247.80
248.21
248.62
249.03
3 DB. B/W 1.84 DEG.
---- AZ. DEGREES...----
6 DB. B/W 2.66 DEG.
TRINIDAD/1325

ANTENNA ELECTRICAL TILT IS 1.57 Deg
3DB points are at 3.23 AND -.68 Deg
6DB points are at 7.78 AND -1.34 Deg
3DB BANDWIDTH = 3.92 Deg

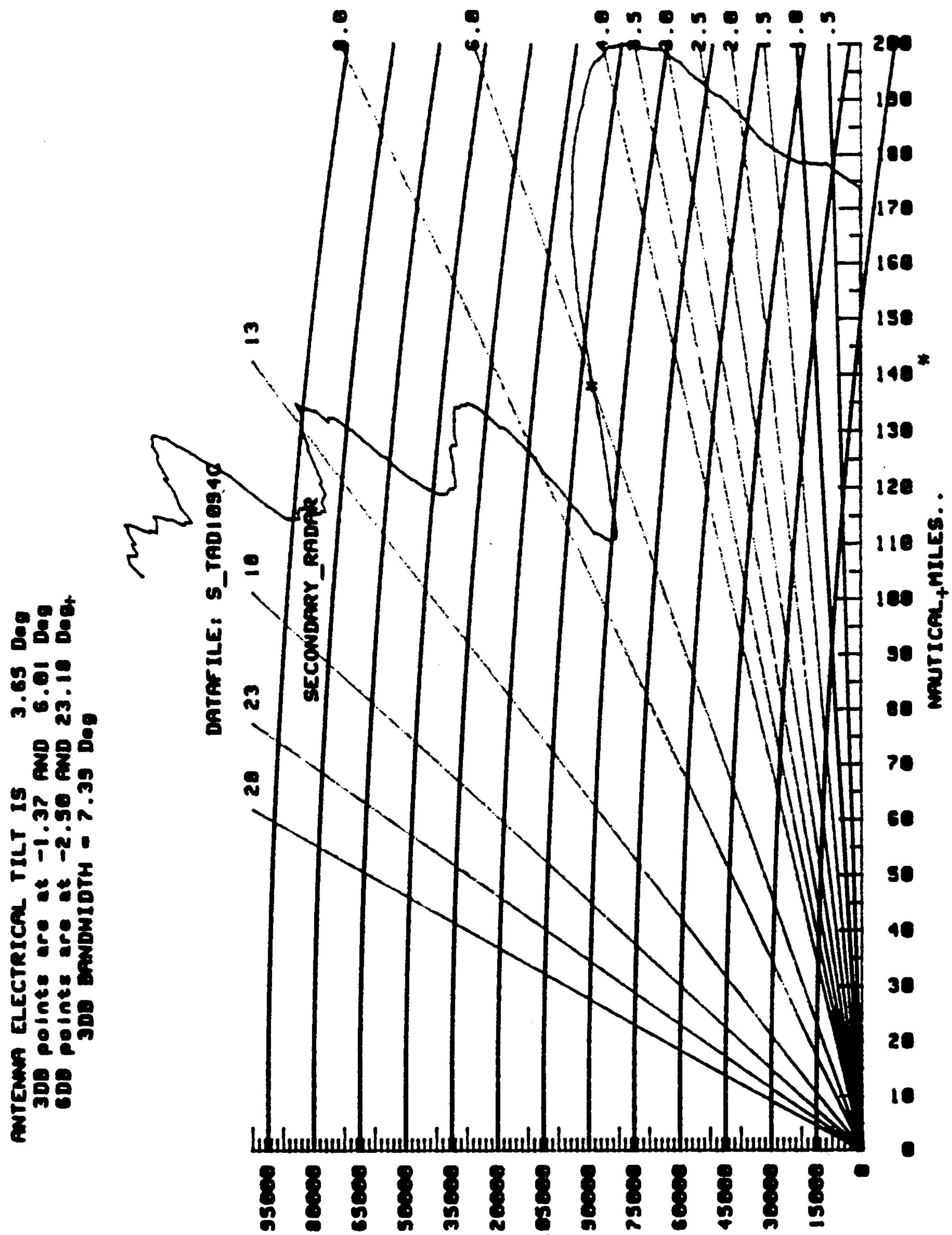


EVALUATE TILT AT 1.5

LOCATION TRINIDAD/132S

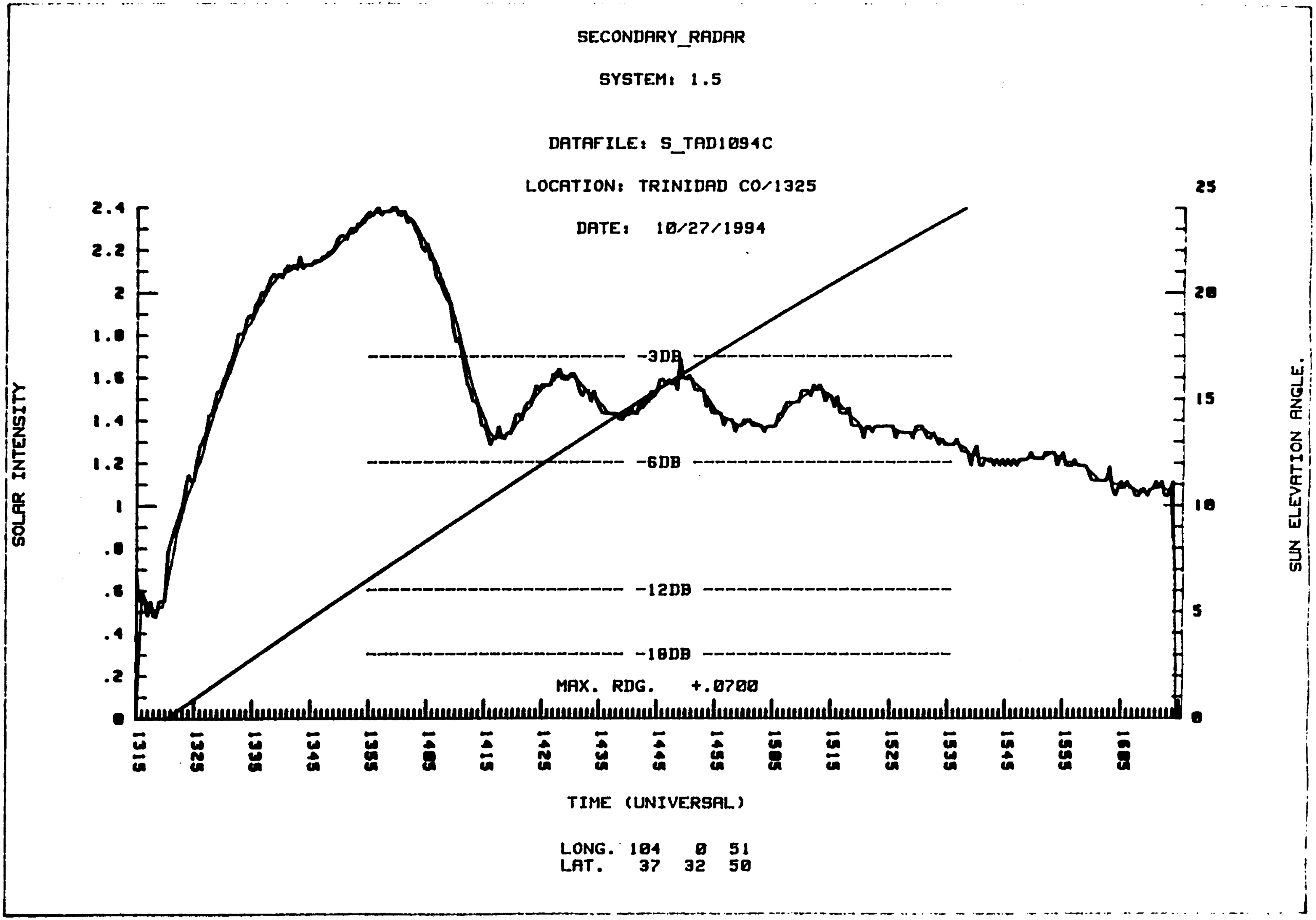

PRIMARY_RADAR
SYSTEM: ARSR-2/1.5
DATAFILE: S_TAD1094B
LOCATION: TRINIDAD/1325
DATE: 10/26/1994
SOLAR INTENSITY
SUN ELEVATION ANGLE.
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0660
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
25
20
15
10
5
0
2130
2140
2150
2200
2210
2220
2230
2240
2250
2300
2310
2320
2330
2340
2350
2400

DEG. ELEV.



EVALUATE TILT AT 1.5

LOCATION TRINIDAD CO/1325



SECONDARY_RADAR
SYSTEM: 1.5
DATAFILE: S_TAD1094C
LOCATION: TRINIDAD CO/1325
DATE: 10/27/1994
SOLAR INTENSITY
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
SUN ELEVATION ANGLE.
25
20
15
10
5
0
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0700
1315
1325
1335
1345
1355
1405
1415
1425
1435
1445
1455
1505
1515
1525
1535
1545
1555
1605
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50

DATAFILE: S_TAD1094C

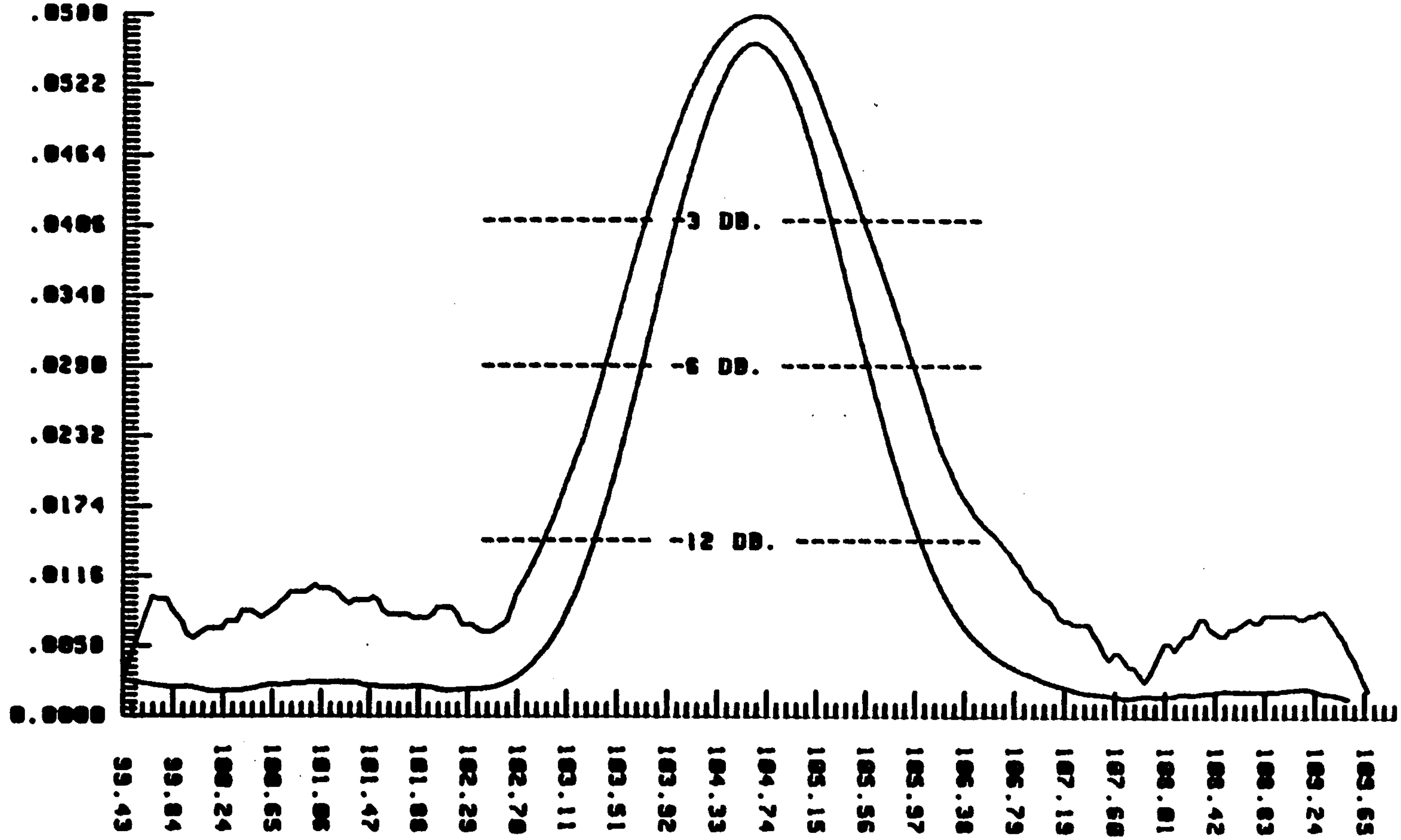
DATE: 10/27/1994

AZIMUTHAL CUT

COMPUTED AZ 110.40

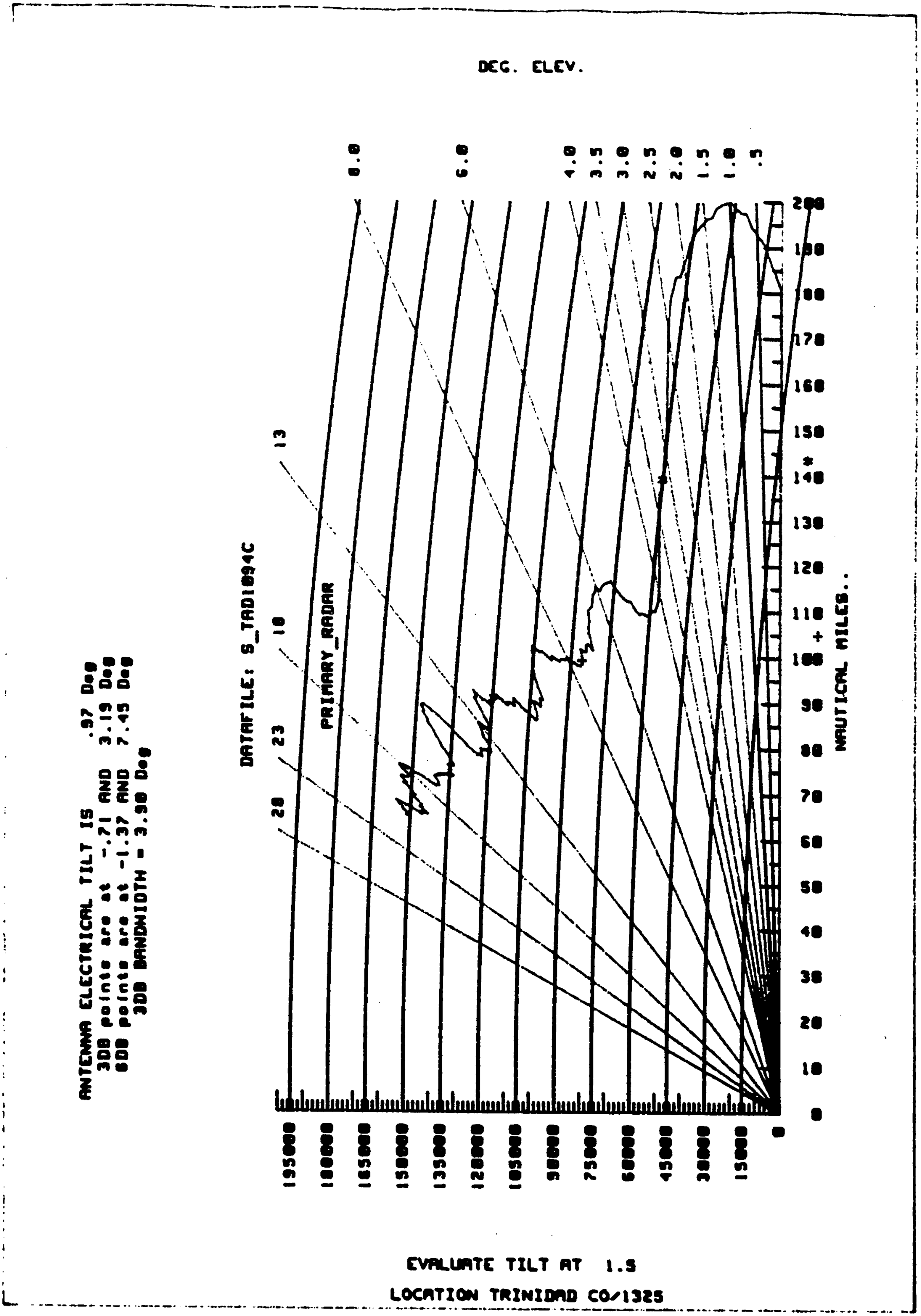
SYSTEM TYPE: 1.5

SCAN PERIOD: 9.63 SEC.

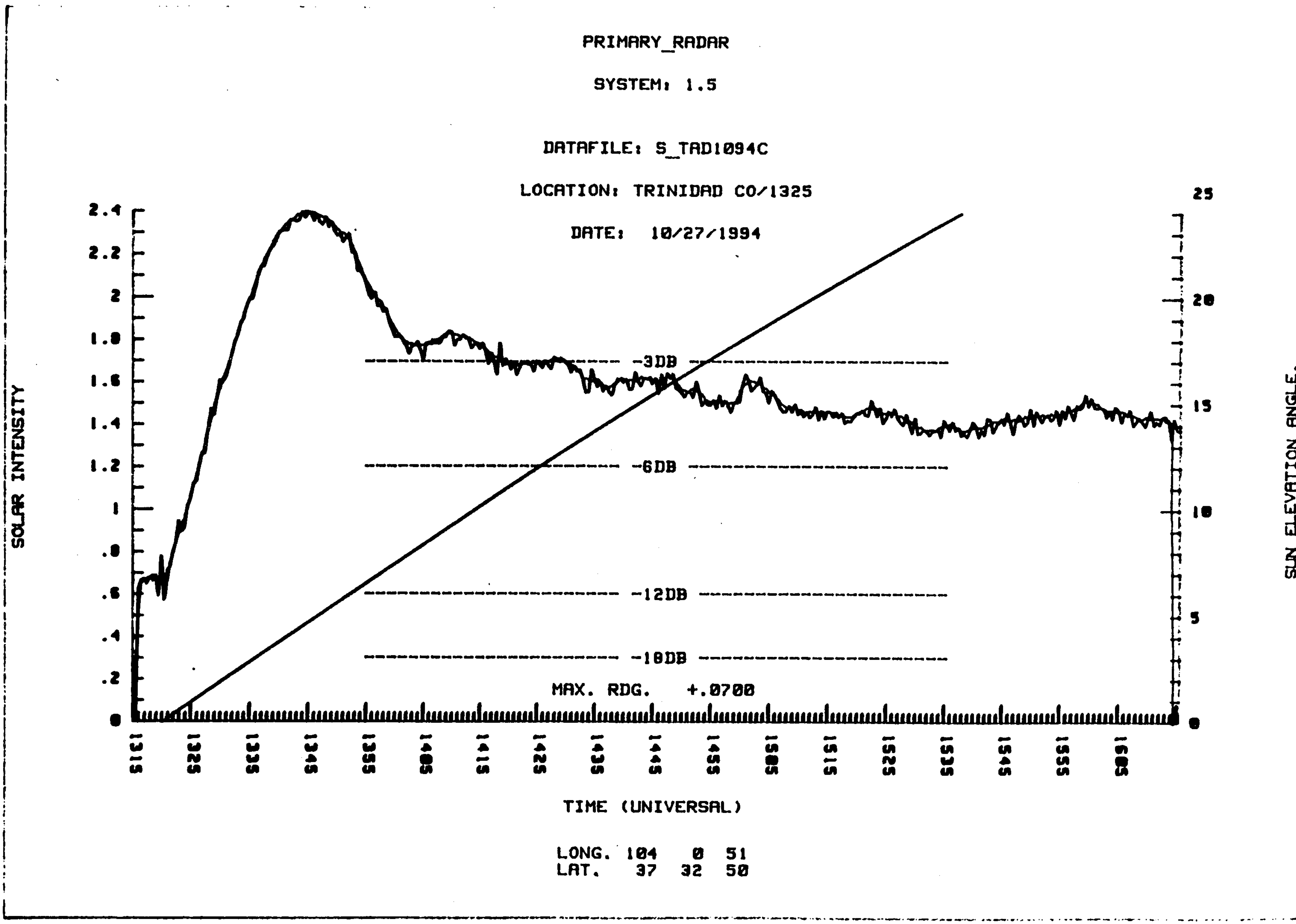


3 DB. B/W 1.80 DEG. ---- AZ. DEGREES...---- 6 DB. B/W 2.53 DEG.

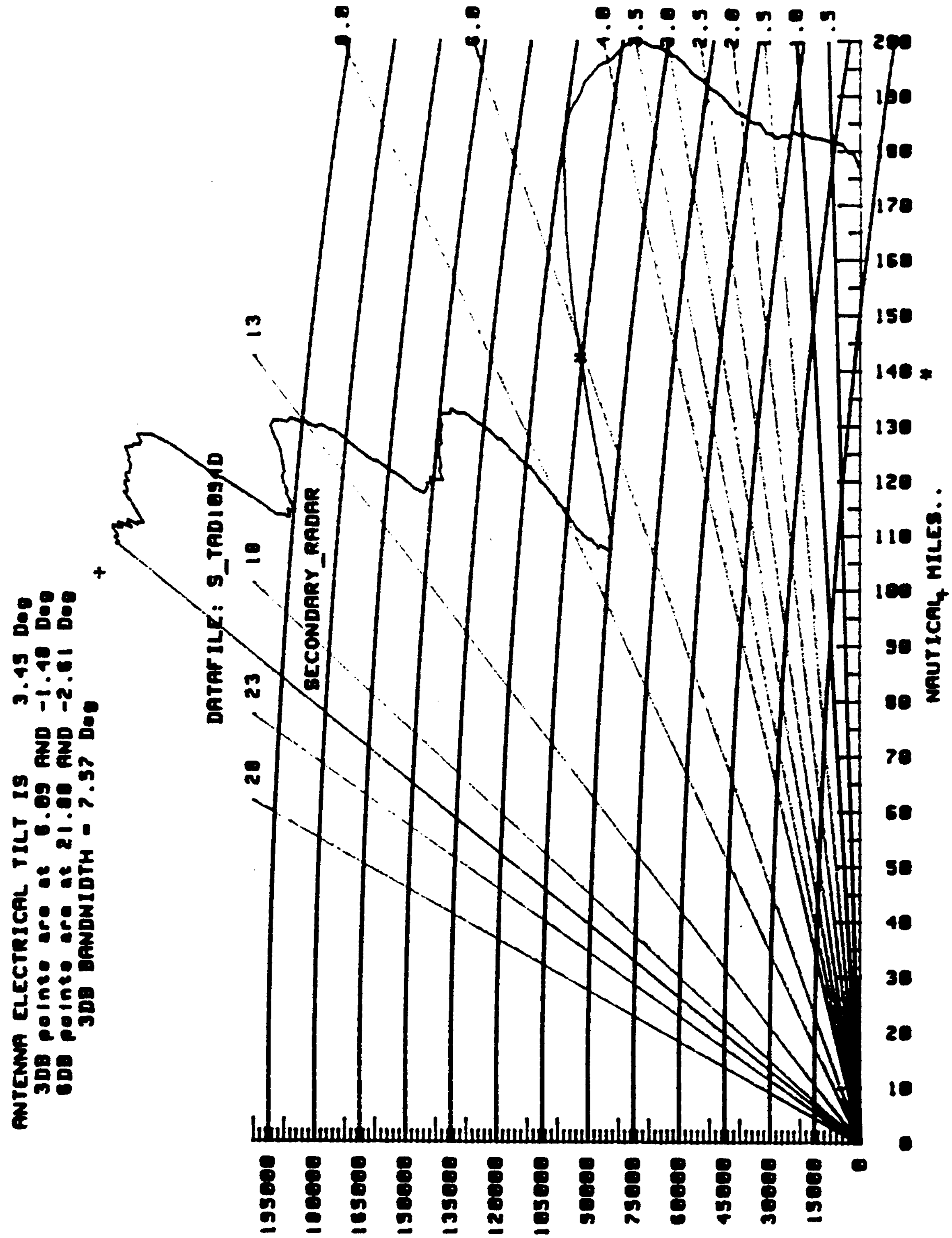
TRINIDAD CO/1325



DEG. ELEV.
8.0
6.0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
13
10
23
28
DATAFILE: S_TRAD1094C
PRIMARY_RADAR
ANTENNA ELECTRICAL TILT IS .97 Deg
3DB points are at -.71 AND 3.19 Deg
6DB points are at -1.37 AND 7.45 Deg
3DB BANDWIDTH = 3.90 Deg
195000
180000
165000
150000
135000
120000
105000
90000
75000
60000
45000
30000
15000
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
NAUTICAL MILES..
EVALUATE TILT AT 1.5
LOCATION TRINIDAD CO/1325


PRIMARY_RADAR
SYSTEM: 1.5
DATAFILE: S_TAD1094C
LOCATION: TRINIDAD CO/1325
DATE: 10/27/1994
SOLAR INTENSITY
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0700
SUN ELEVATION ANGLE.
25
20
15
10
5
0
1315
1325
1335
1345
1355
1405
1415
1425
1435
1445
1455
1505
1515
1525
1535
1545
1555
1605
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50

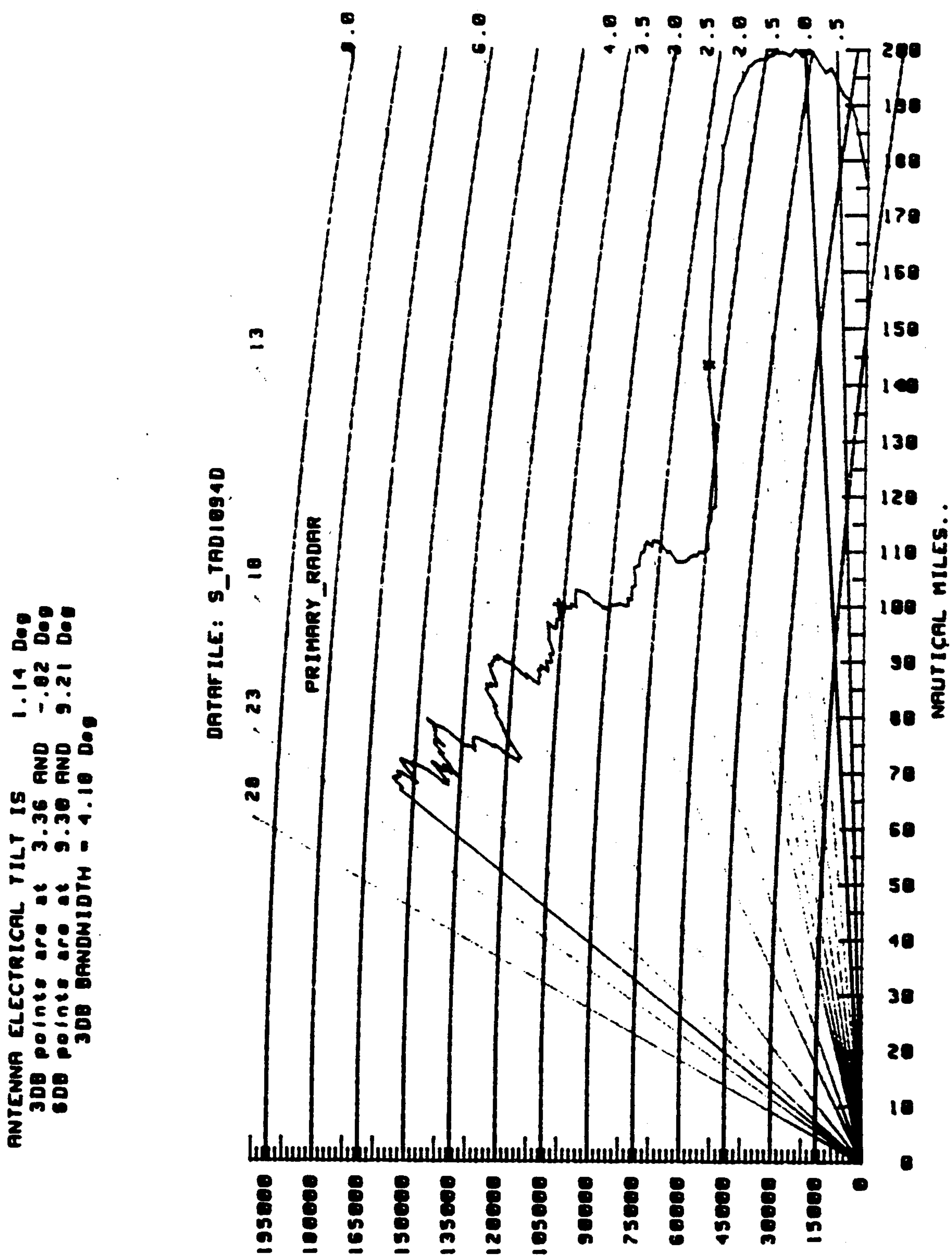
DEG. ELEV.



EVALUATE TILT AT 1.5

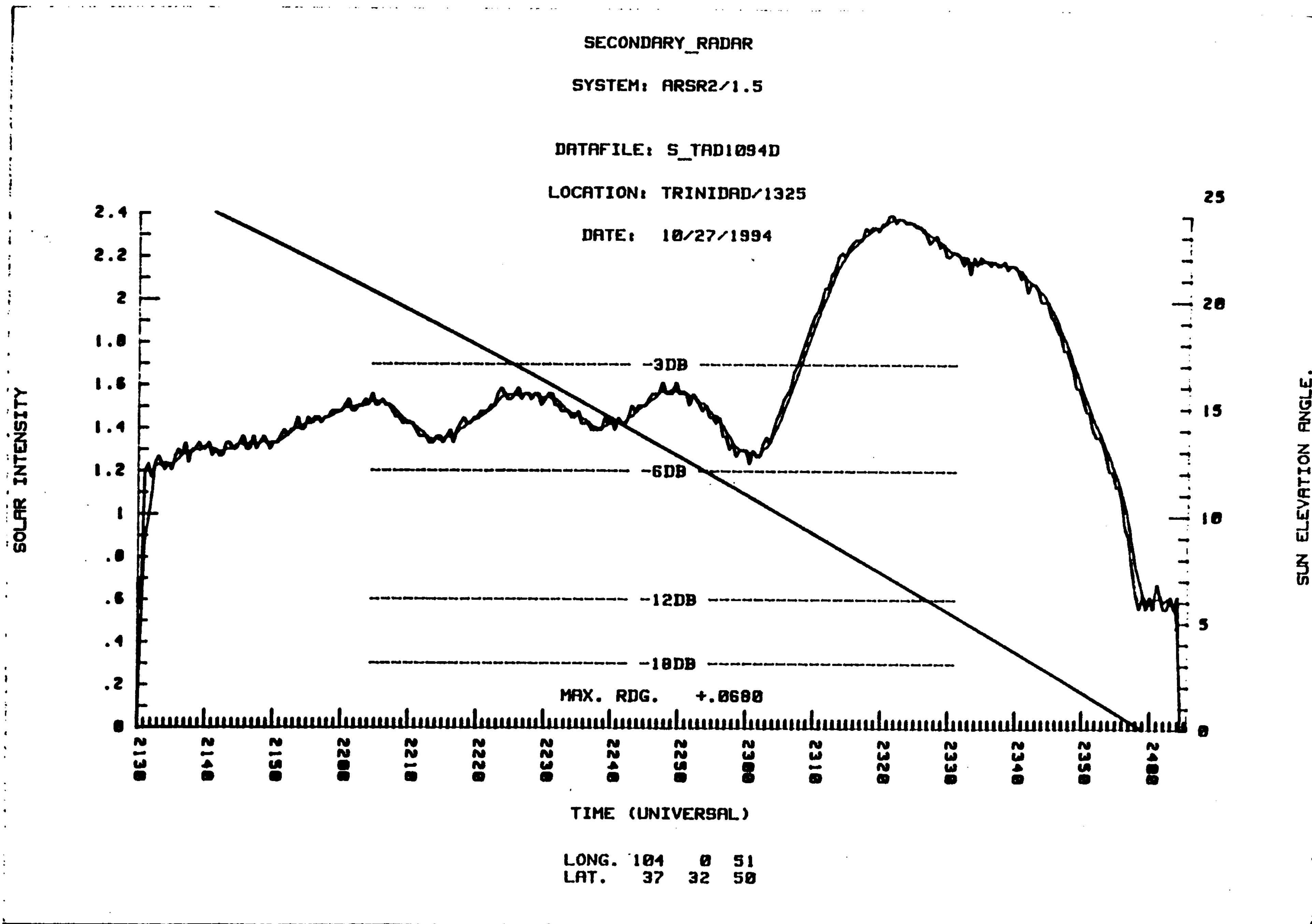
LOCATION TRINIDAD/1325

DEG. ELEV.



EVALUATE TILT AT 1.5

LOCATION TRINIDAD/1325


SECONDARY_RADAR
SYSTEM: ARSR2/1.5
DATAFILE: S_TAD1094D
LOCATION: TRINIDAD/1325
DATE: 10/27/1994
SOLAR INTENSITY
SUN ELEVATION ANGLE.
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0680
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
25
20
15
10
5
0
2130
2140
2150
2200
2210
2220
2230
2240
2250
2300
2310
2320
2330
2340
2350
2400

DATAFILE: S_TADI894D

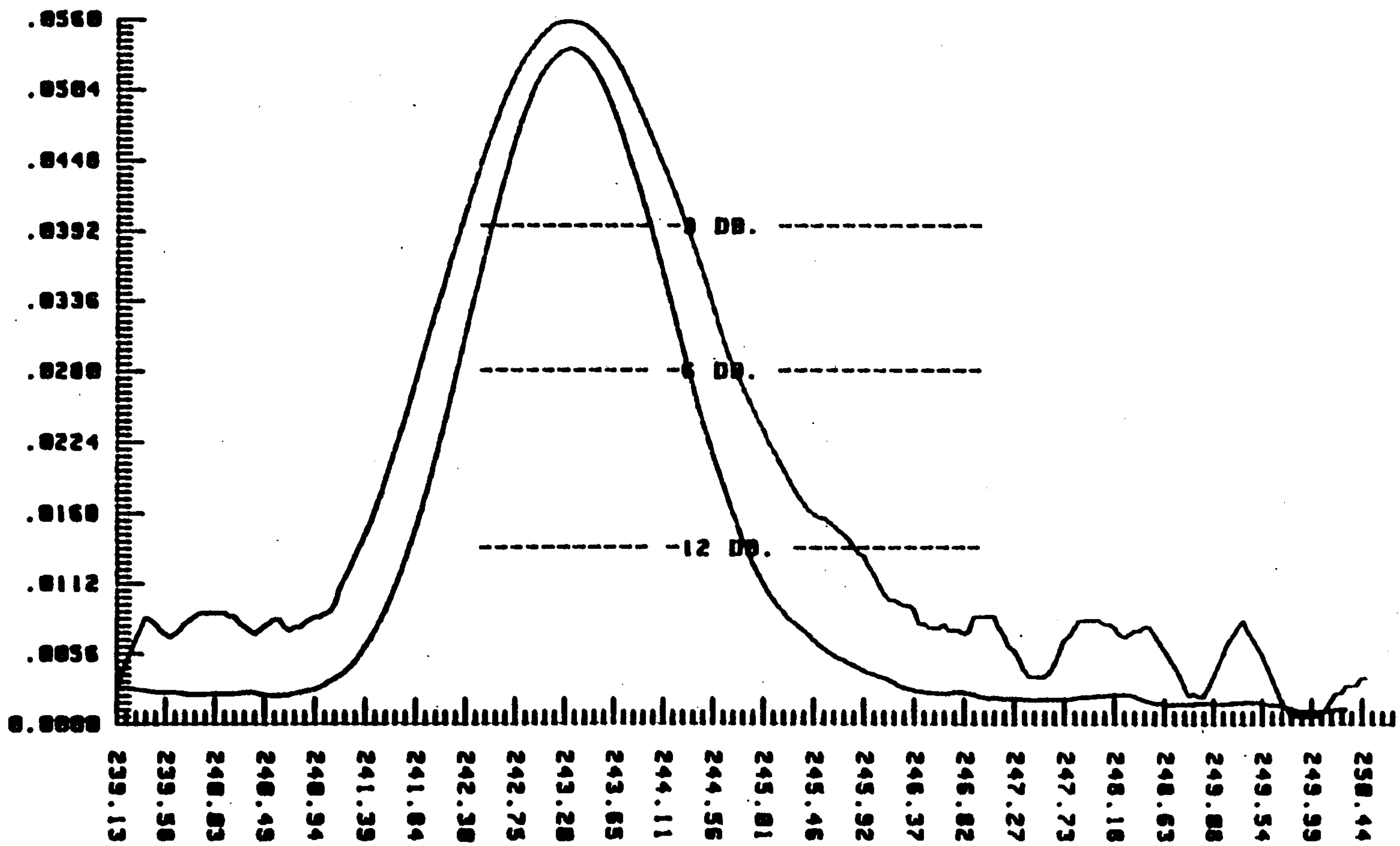
DATE: 10/27/1994

AZIMUTHAL CUT

SYSTEM TYPE: ARSR2/1.5

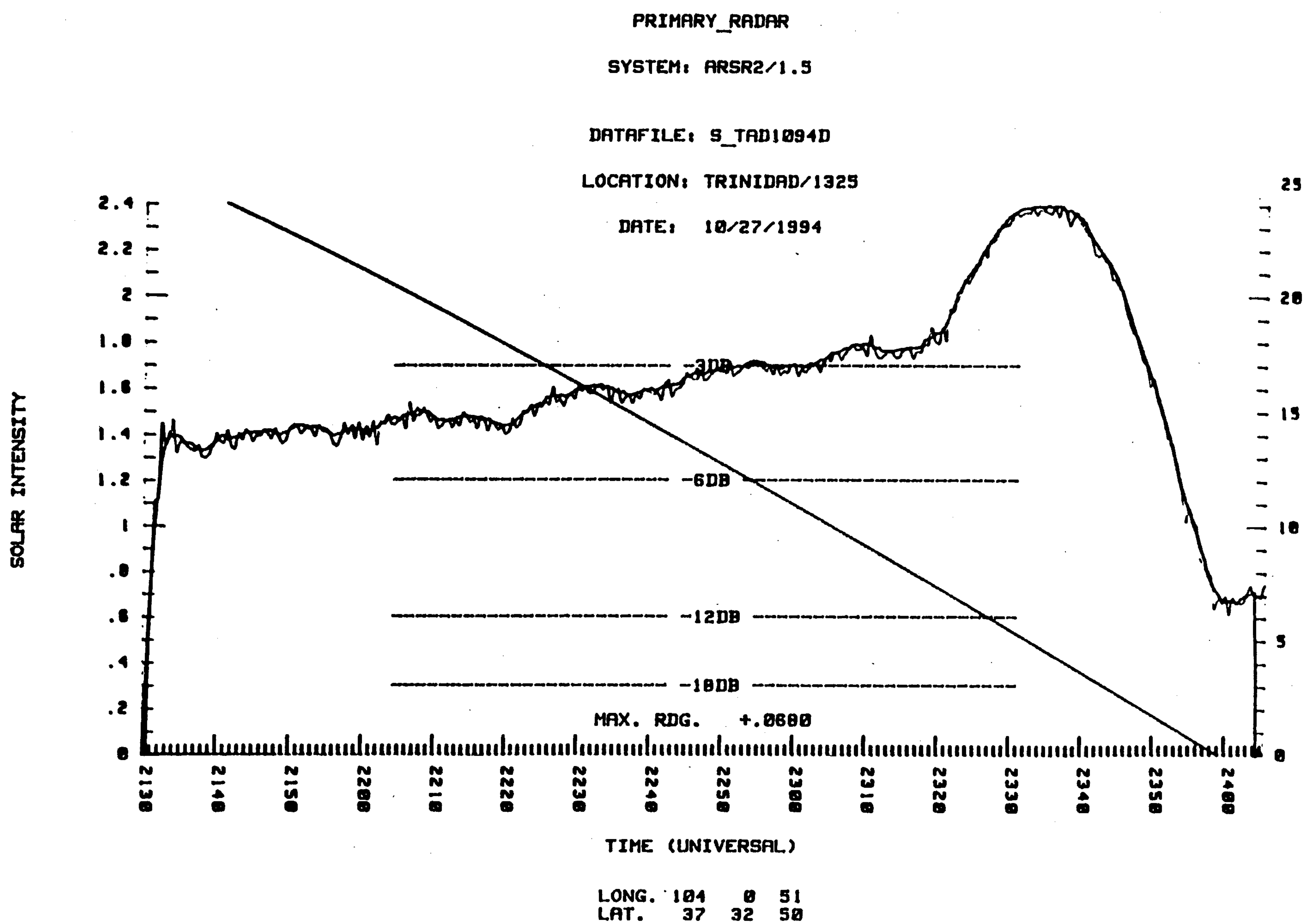
SCAN PERIOD: 9.64 SEC.

COMPUTED AZ 249.35



3 DB. B/W 2.08 DEG. ---- AZ. DEGREES...---- 6 DB. B/W 2.90 DEG.

TRINIDAD/1325

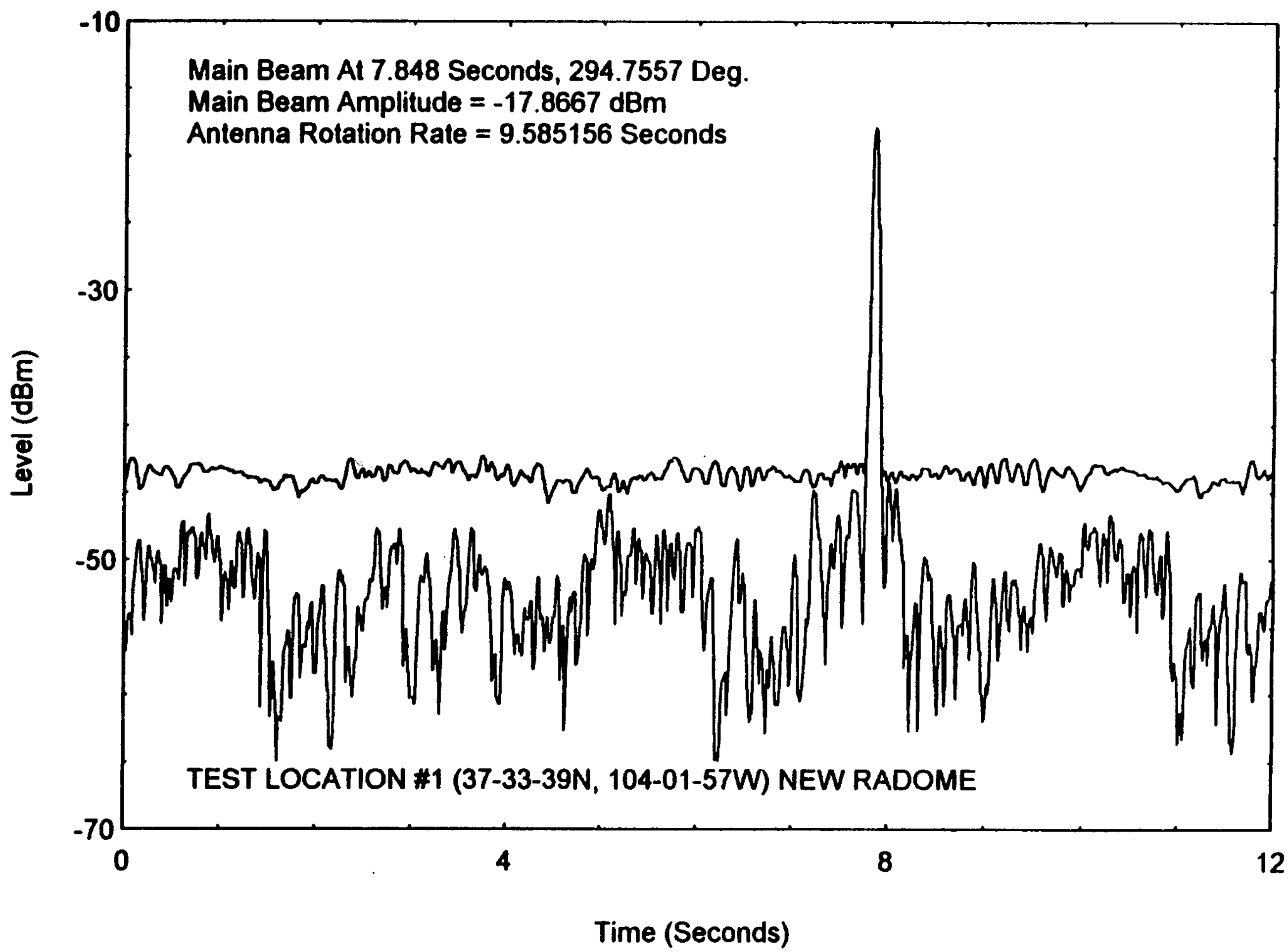

PRIMARY_RADAR
SYSTEM: ARSR2/1.5
DATAFILE: S_TAD1094D
LOCATION: TRINIDAD/1325
DATE: 10/27/1994
SOLAR INTENSITY
SUN ELEVATION ANGLE.
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0600
2130
2140
2150
2200
2210
2220
2230
2240
2250
2300
2310
2320
2330
2340
2350
2400
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50

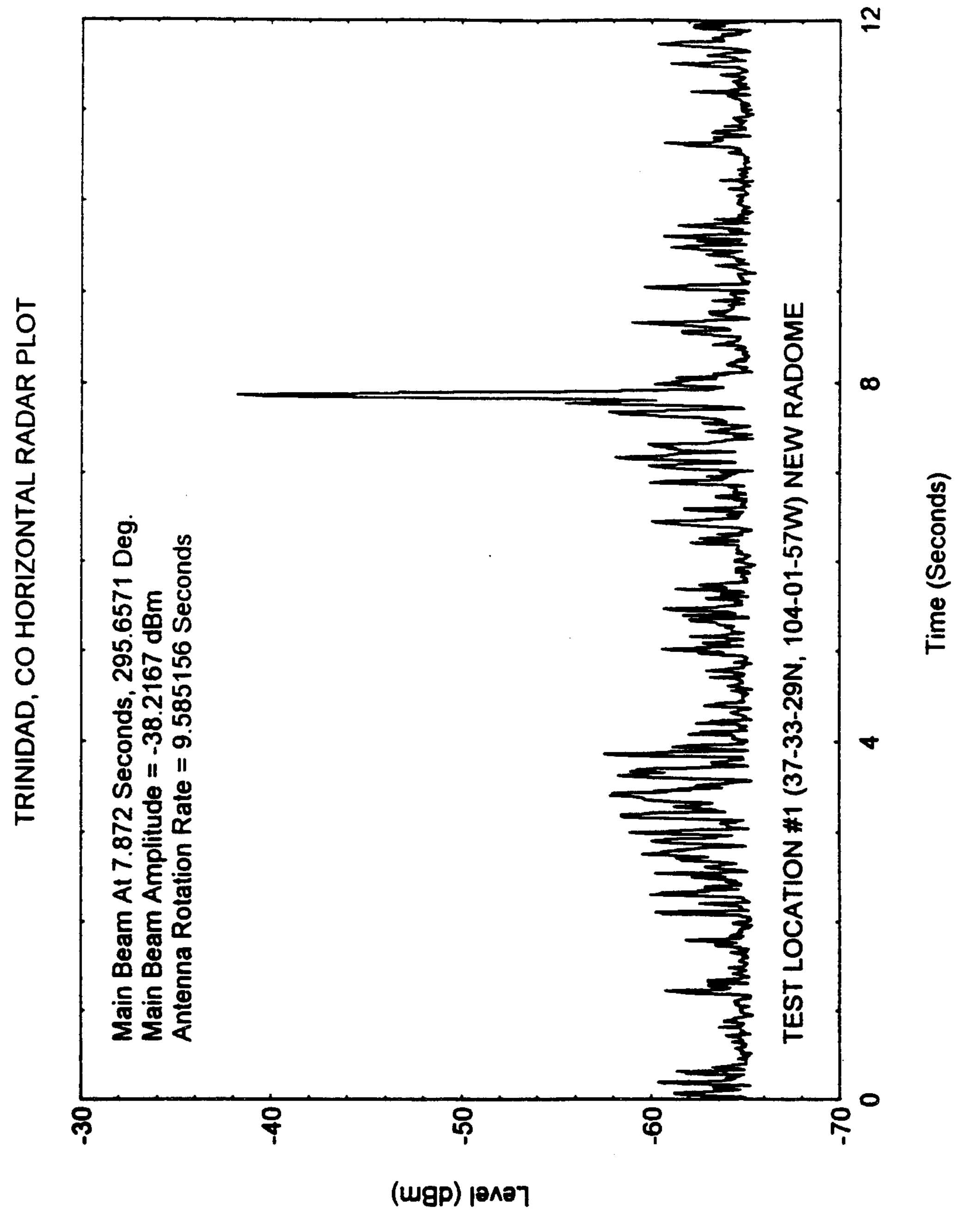
ATTACHMENT 3

NEW RADOME

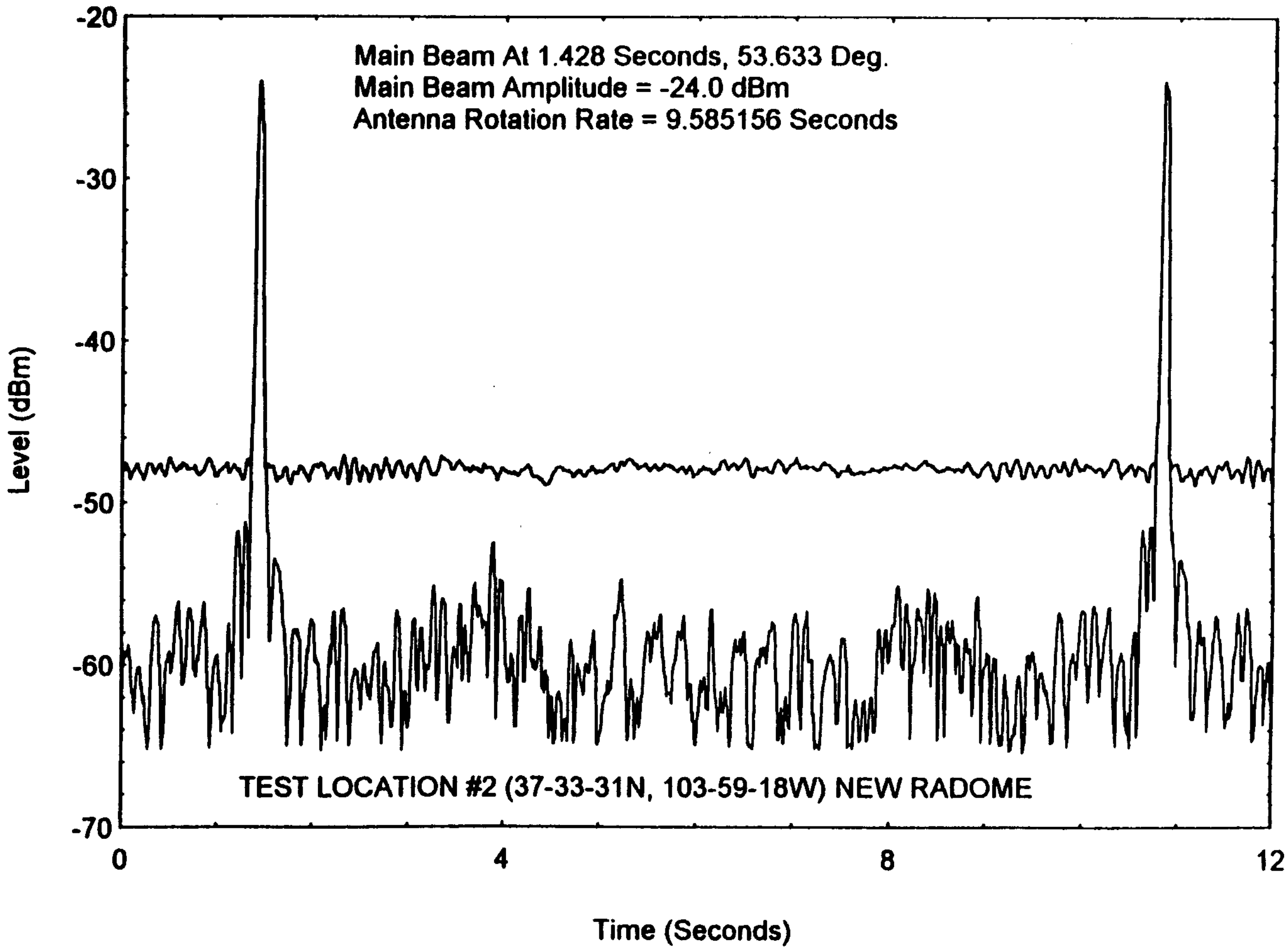
360° Horizontal Plots
Beam Width Plots
Vertical Plots (Solars)

TRINIDAD, CO HORIZONTAL BEACON PLOT

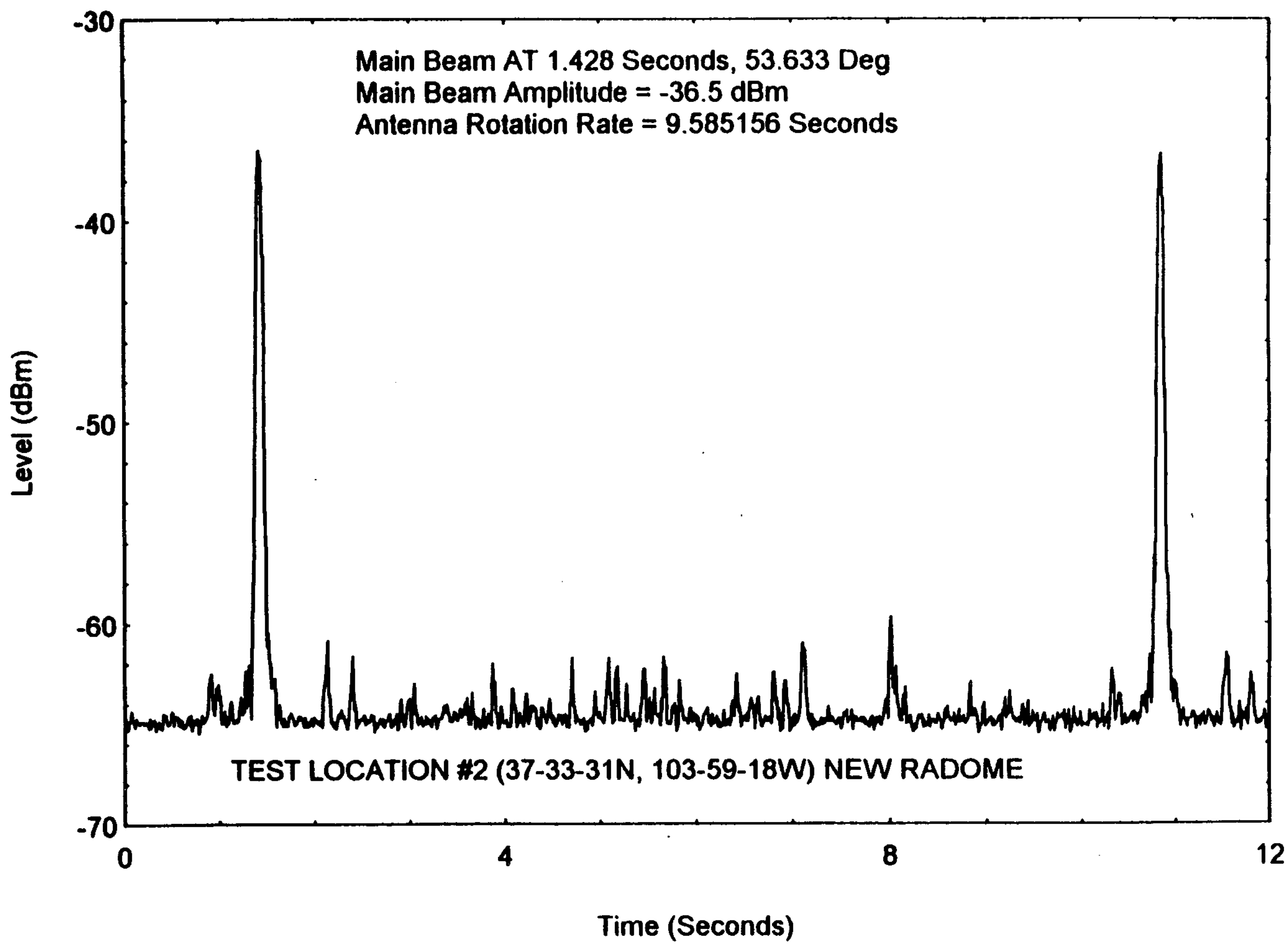



TRINIDAD, CO HORIZONTAL RADAR PLOT
Main Beam At 7.872 Seconds, 295.6571 Deg.
Main Beam Amplitude = -38.2167 dBm
Antenna Rotation Rate = 9.585156 Seconds
TEST LOCATION #1 (37-33-29N, 104-01-57W) NEW RADOME
Level (dBm)
-30
-40
-50
-60
-70
0
4
8
12
Time (Seconds)

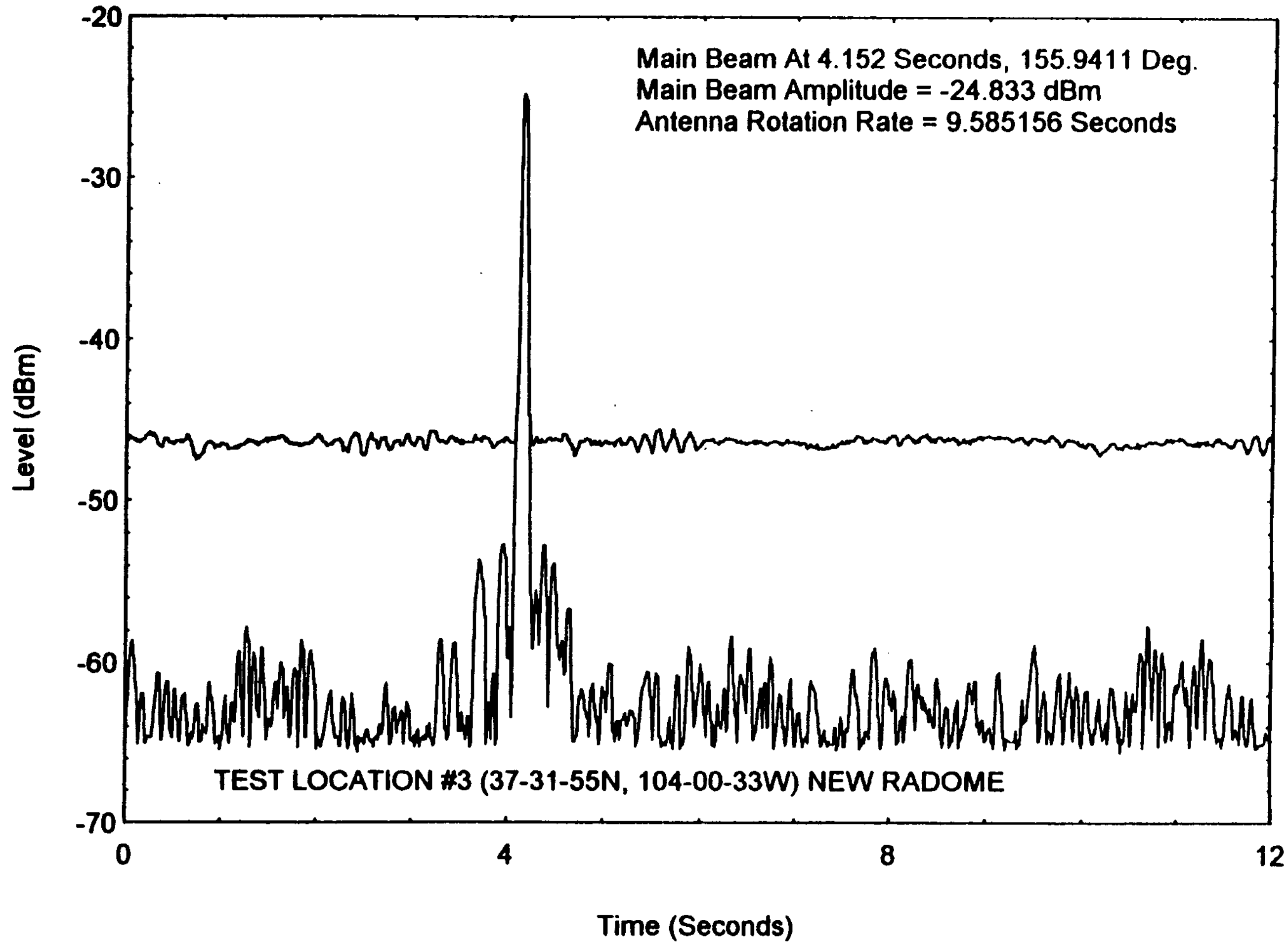
TRINIDAD, CO HORIZONTAL BEACON PLOT



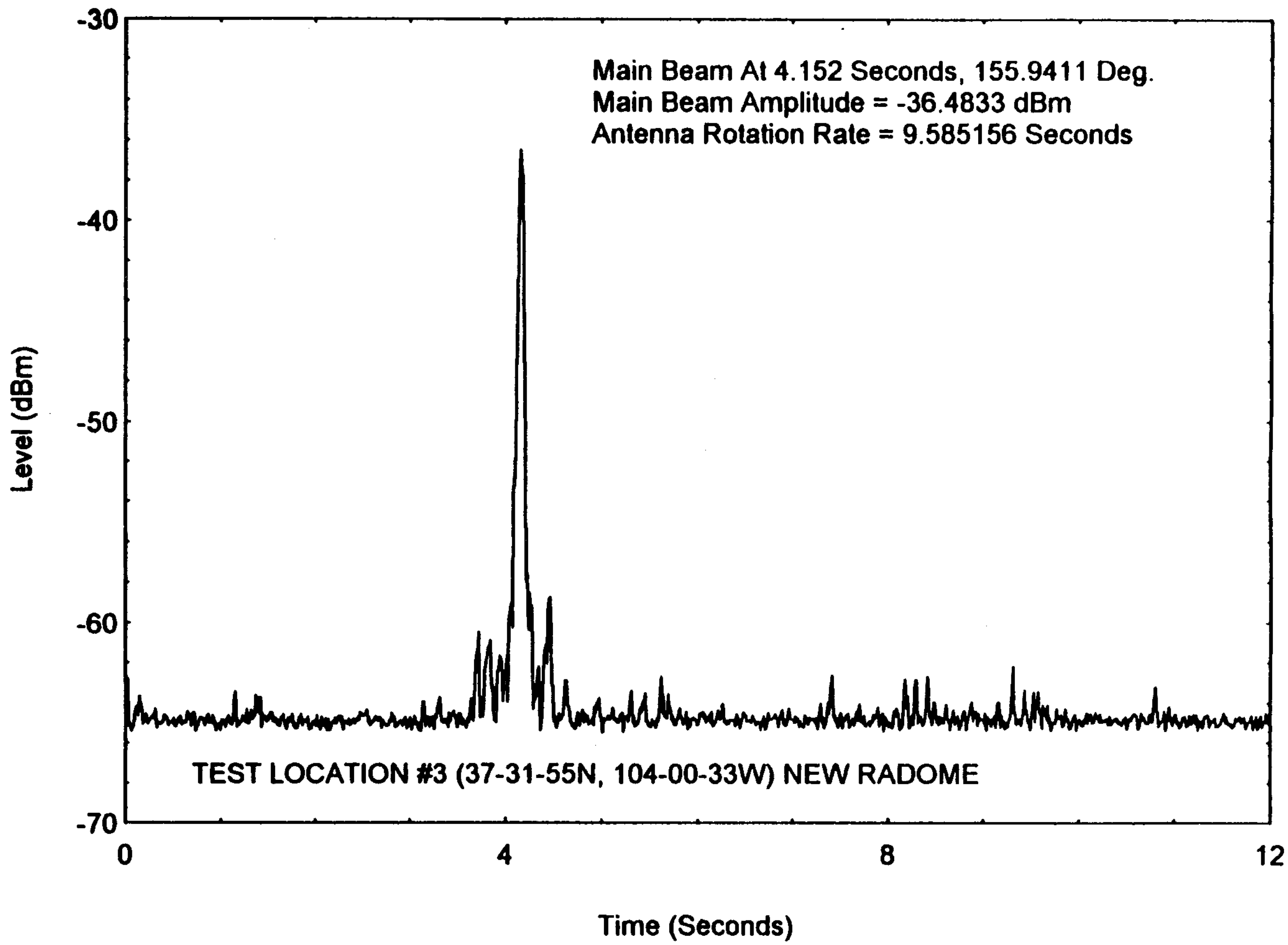
TRINIDAD, CO HORIZONTAL RADAR PLOT

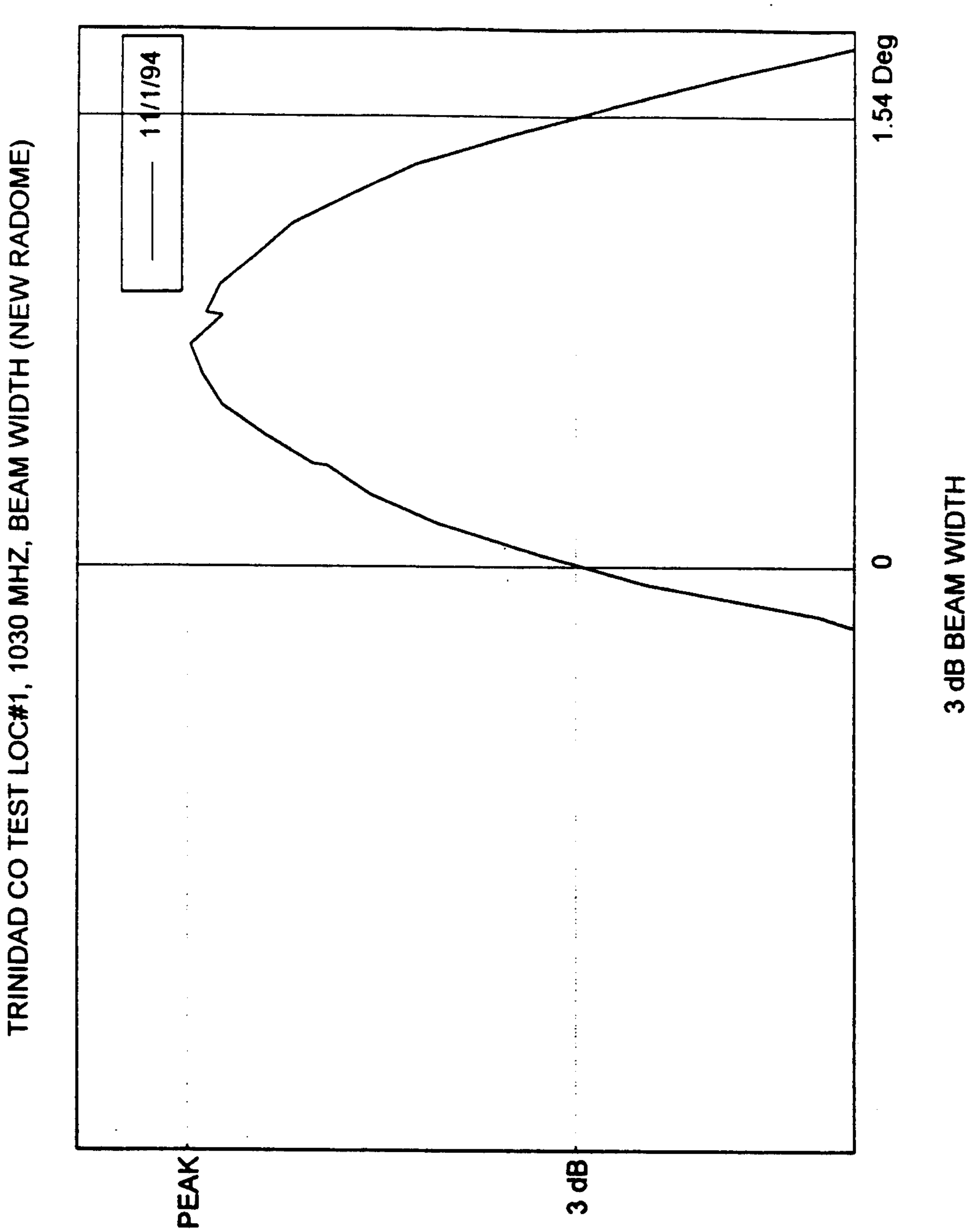


TRINIDAD, CO HORIZONTAL BEACON PLOT



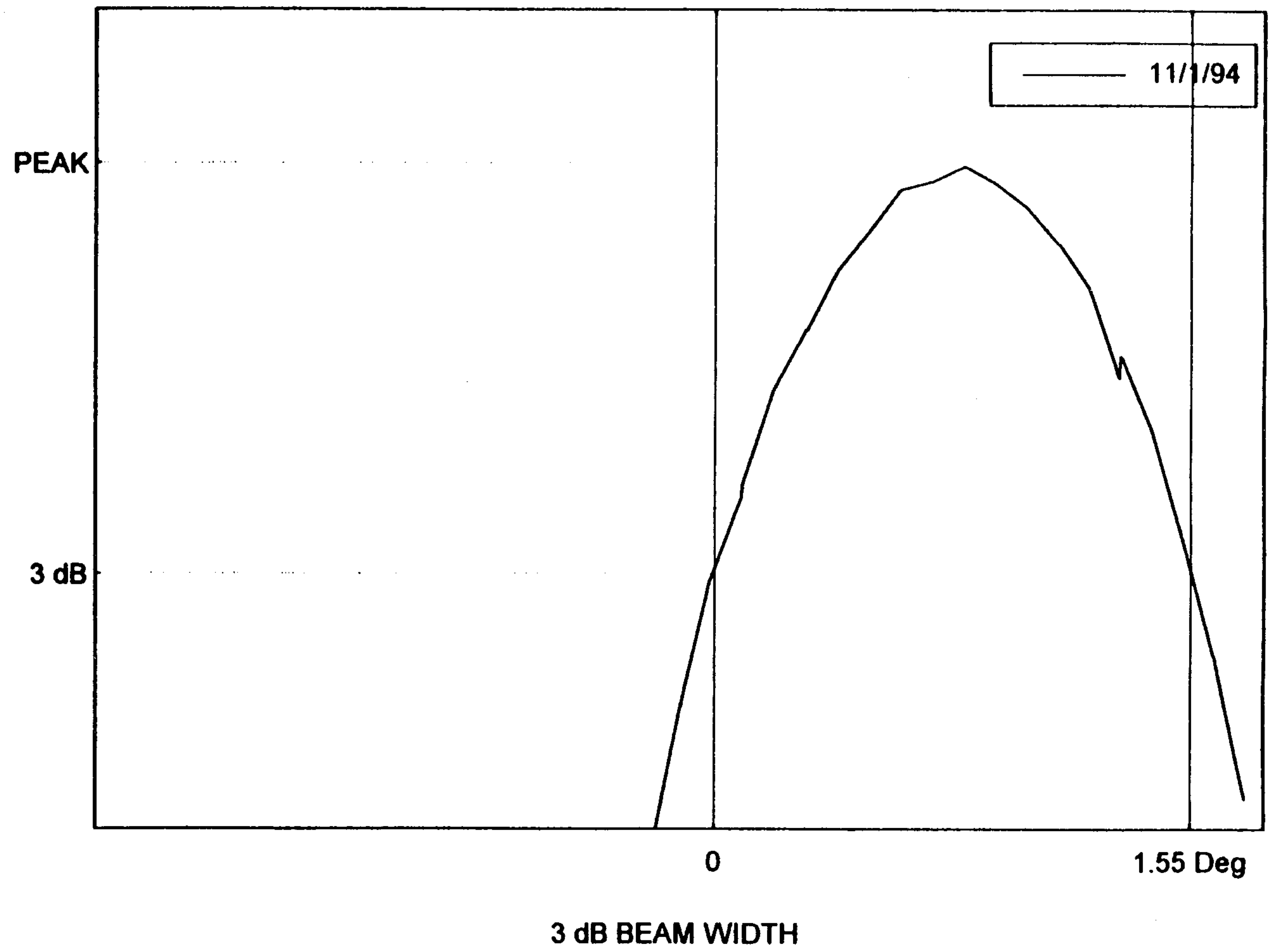
TRINIDAD, CO HORIZONTAL RADAR PLOT



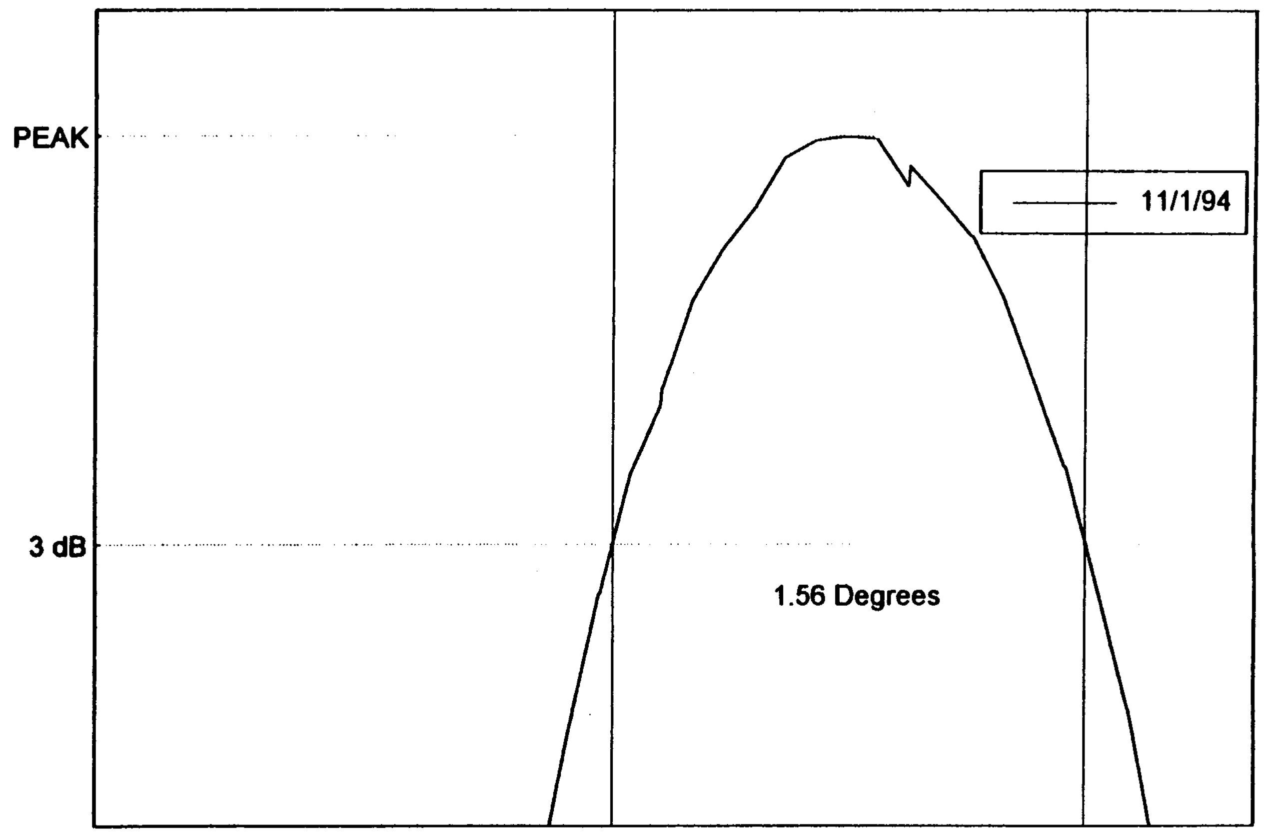


TRINIDAD CO TEST LOC#1, 1030 MHZ, BEAM WIDTH (NEW RADOME)
11/1/94
PEAK
3 dB
0
1.54 Deg
3 dB BEAM WIDTH

TRINIDAD CO TEST LOC#2, 1030 MHZ, BEAM WIDTH (NEW RADOME)

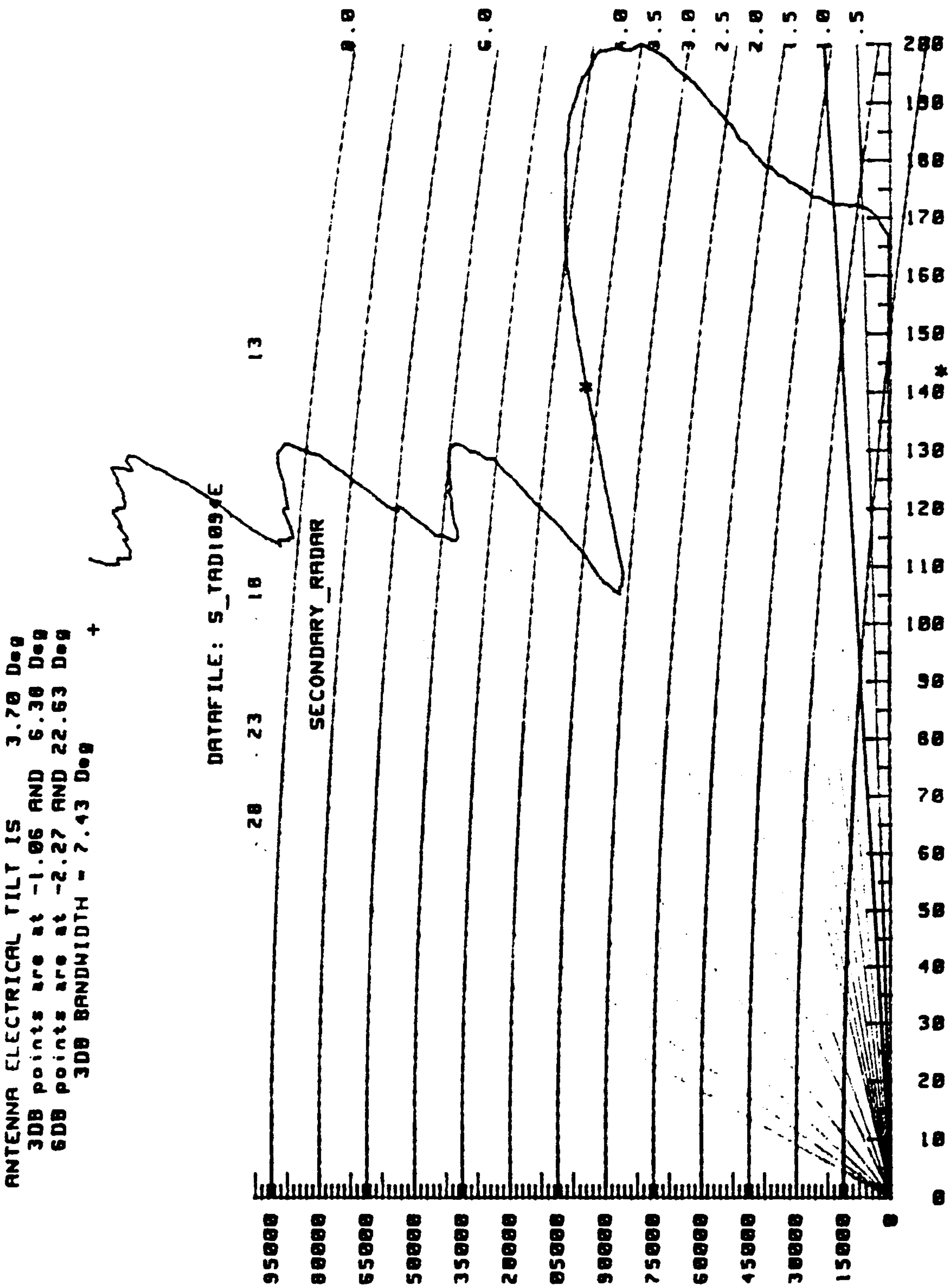


TRINIDAD CO TEST LOC#3, 1030 MHZ, BEAM WIDTH (NEW RADOME)



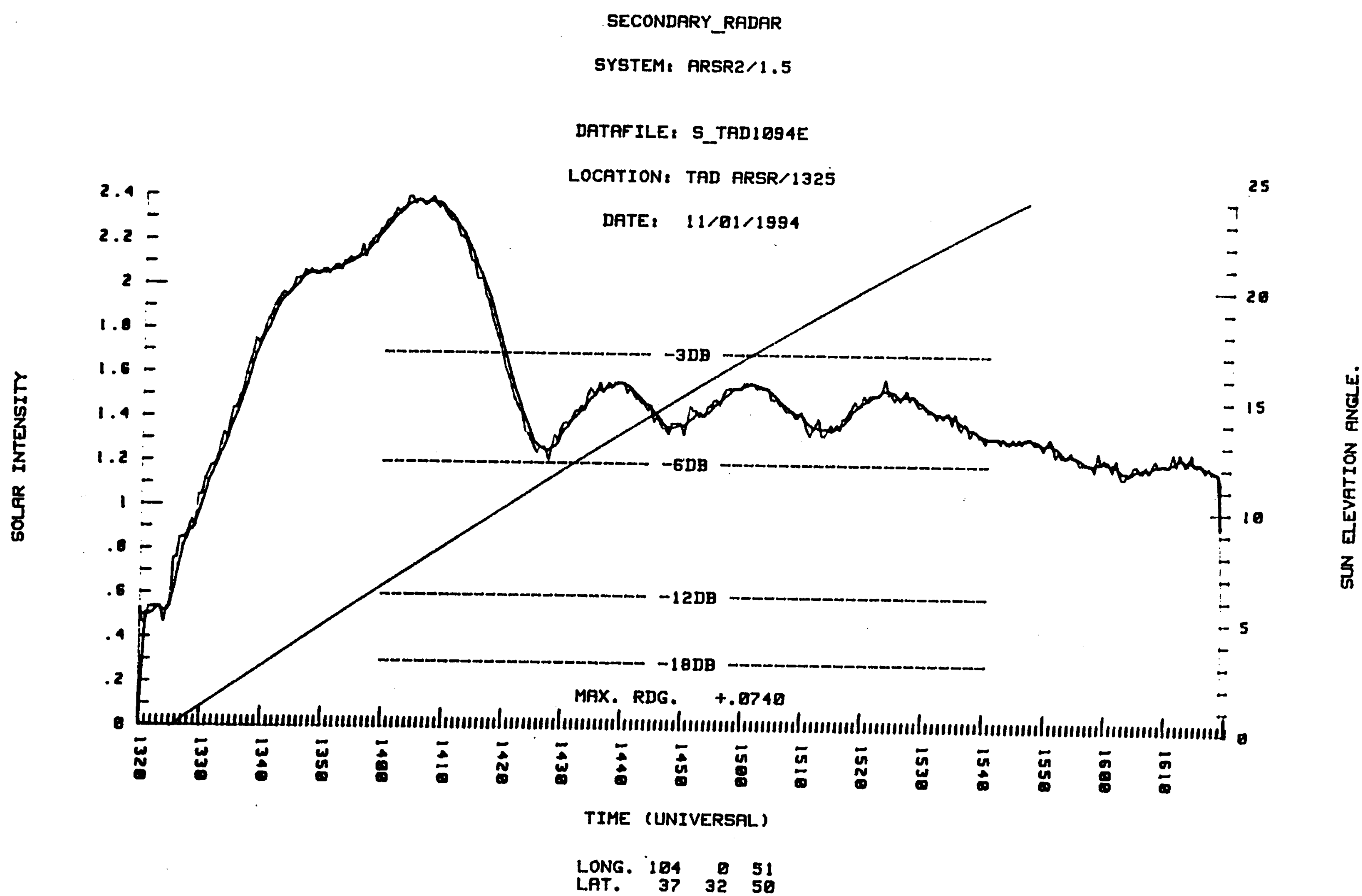
3 dB BEAM WIDTH

DEG. ELEV.



EVALUATE TILT AT 1.5

LOCATION TAD ARSR/1325


SECONDARY_RADAR
SYSTEM: ARSR2/1.5
DATAFILE: S_TAD1094E
LOCATION: TAD ARSR/1325
DATE: 11/01/1994
SOLAR INTENSITY
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0740
SUN ELEVATION ANGLE.
25
20
15
10
5
0
1320
1330
1340
1350
1400
1410
1420
1430
1440
1450
1500
1510
1520
1530
1540
1550
1600
1610
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50

DATAFILE: S_TAD1094E

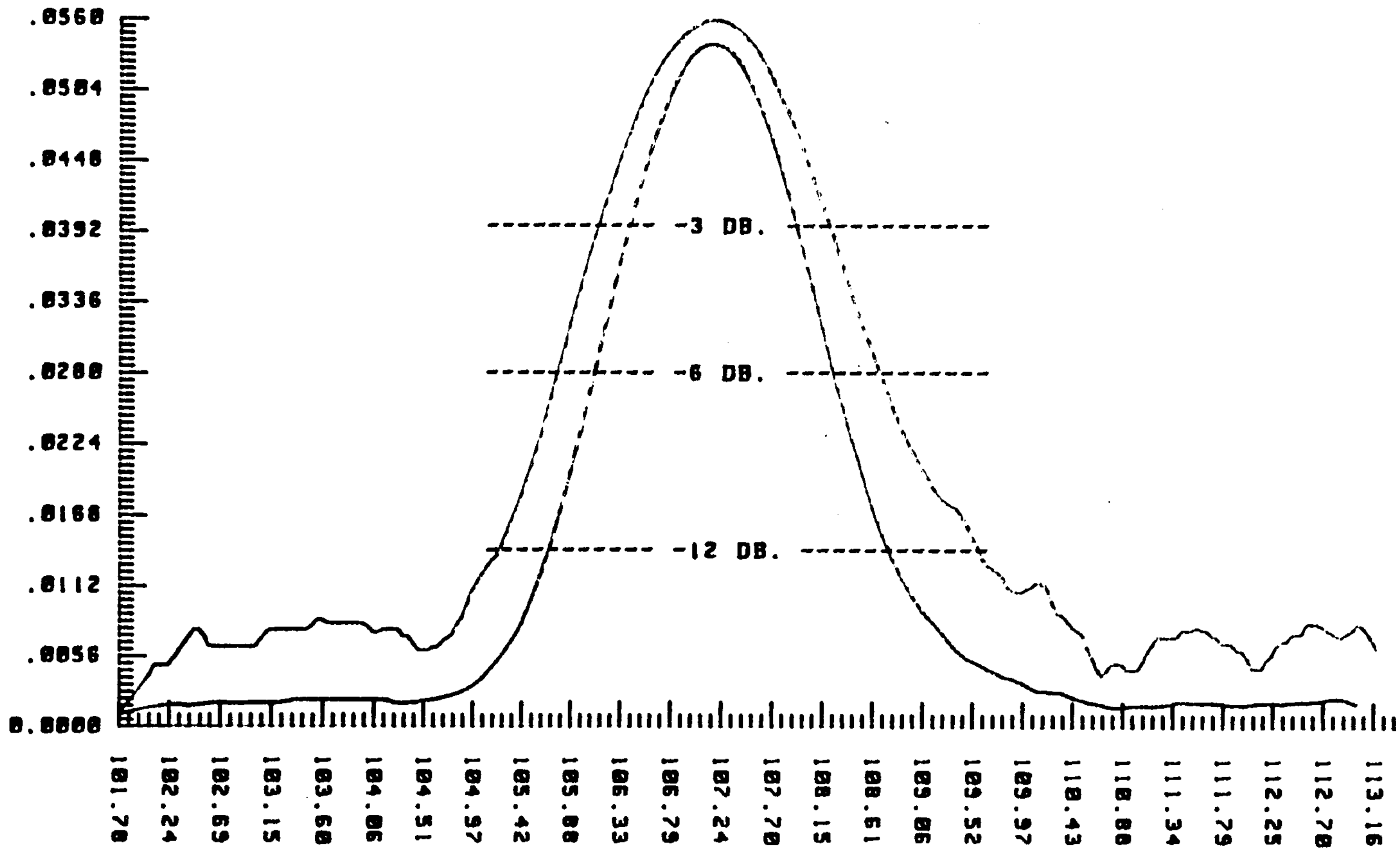
DATE: 11/01/1994

AZIMUTHAL CUT

SYSTEM TYPE: ARSR2/1.5

SCAN PERIOD: 9.58 SEC.

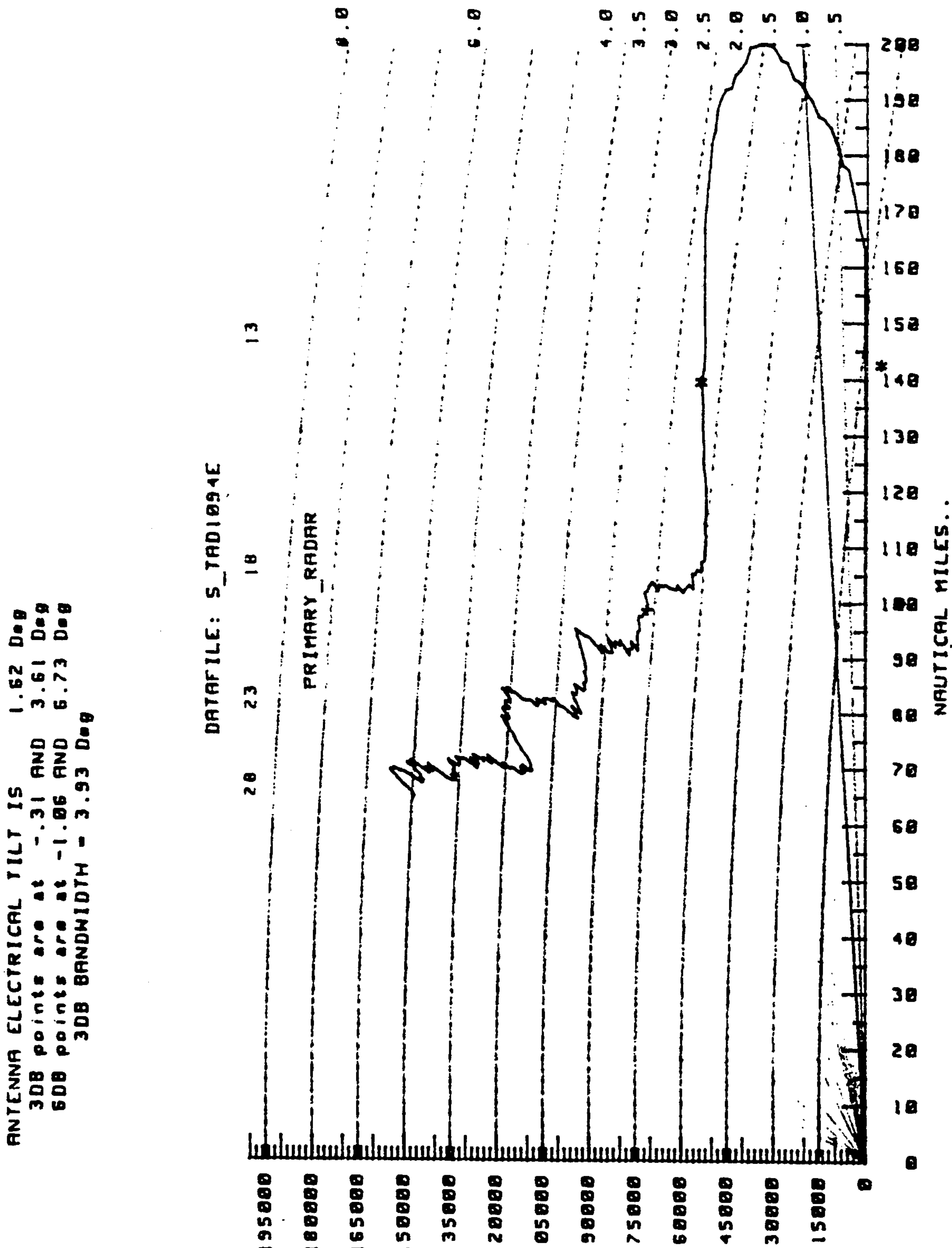
COMPUTED AZ 112.58



3 DB. B/W 2.09 DEG. ---- AZ. DEGREES...---- 6 DB. B/W 2.91 DEG.

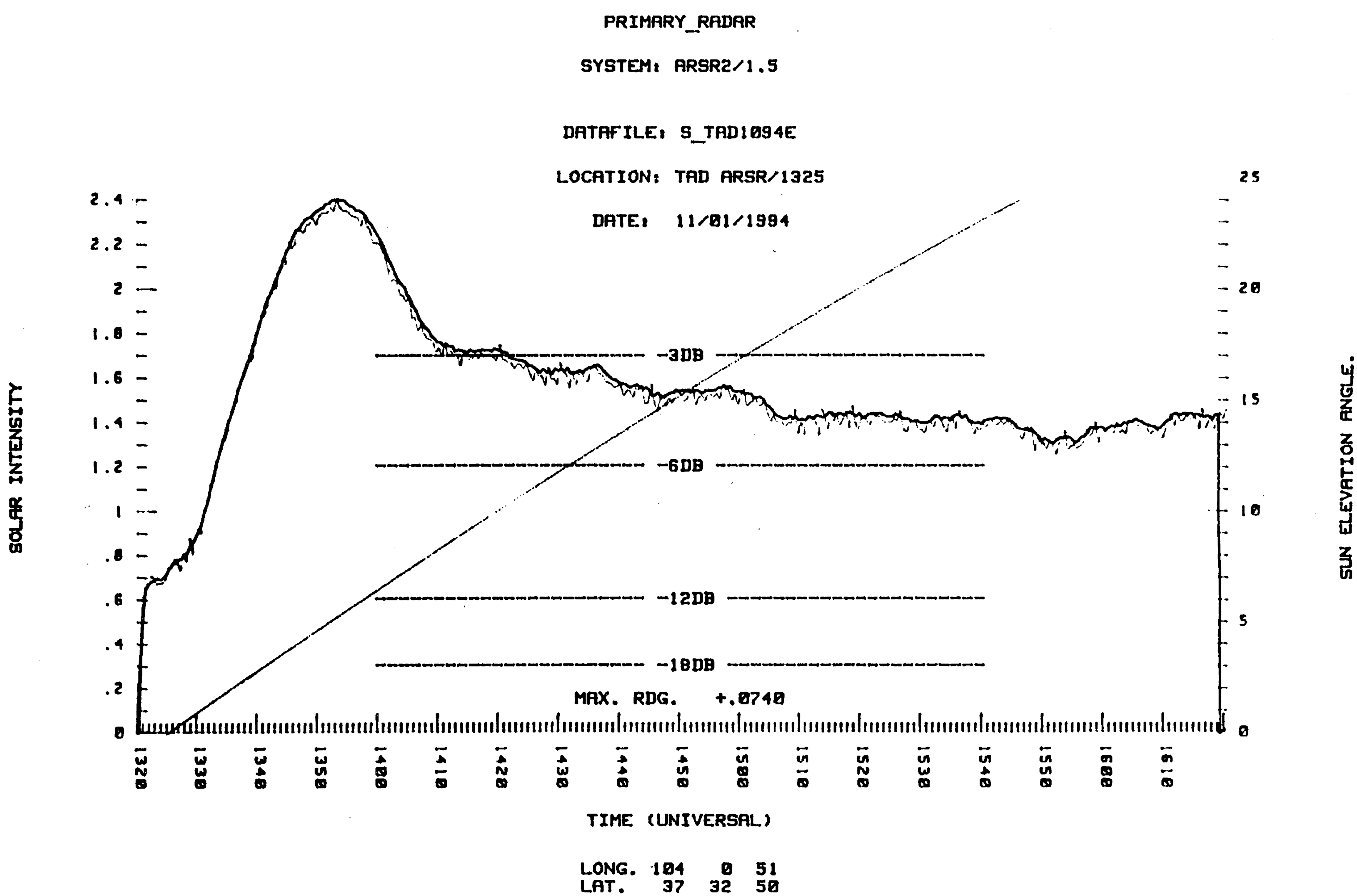
TAD ARSR/1325

DEG. ELEV.



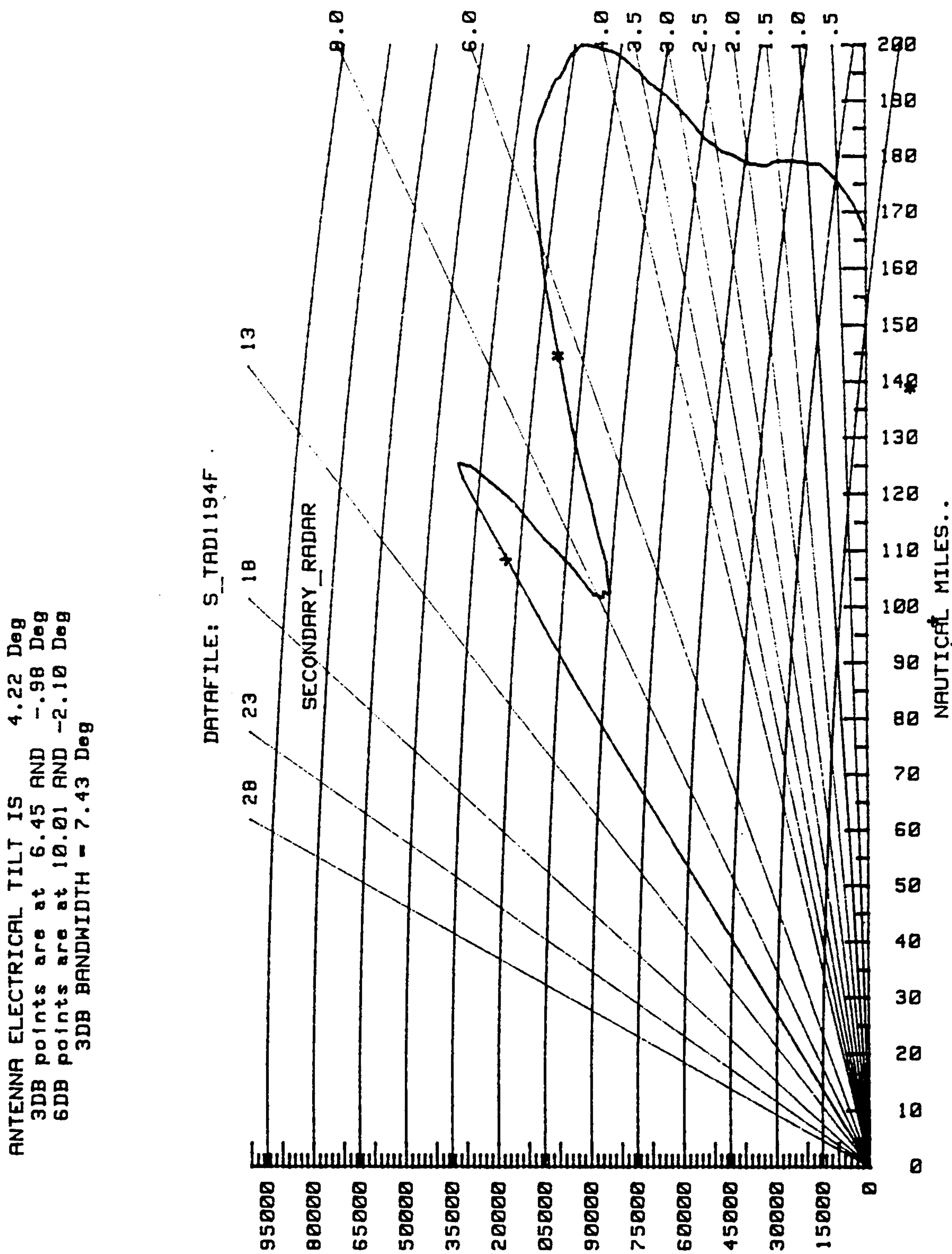
EVALUATE TILT AT 1.5

LOCATION TAD ARSR/1325


PRIMARY_RADAR
SYSTEM: ARSR2/1.5
DATAFILE: S_TAD1094E
LOCATION: TAD ARSR/1325
DATE: 11/01/1984
SOLAR INTENSITY
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
SUN ELEVATION ANGLE.
25
20
15
10
5
0
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0740
1320
1330
1340
1350
1400
1410
1420
1430
1440
1450
1500
1510
1520
1530
1540
1550
1600
1610
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50

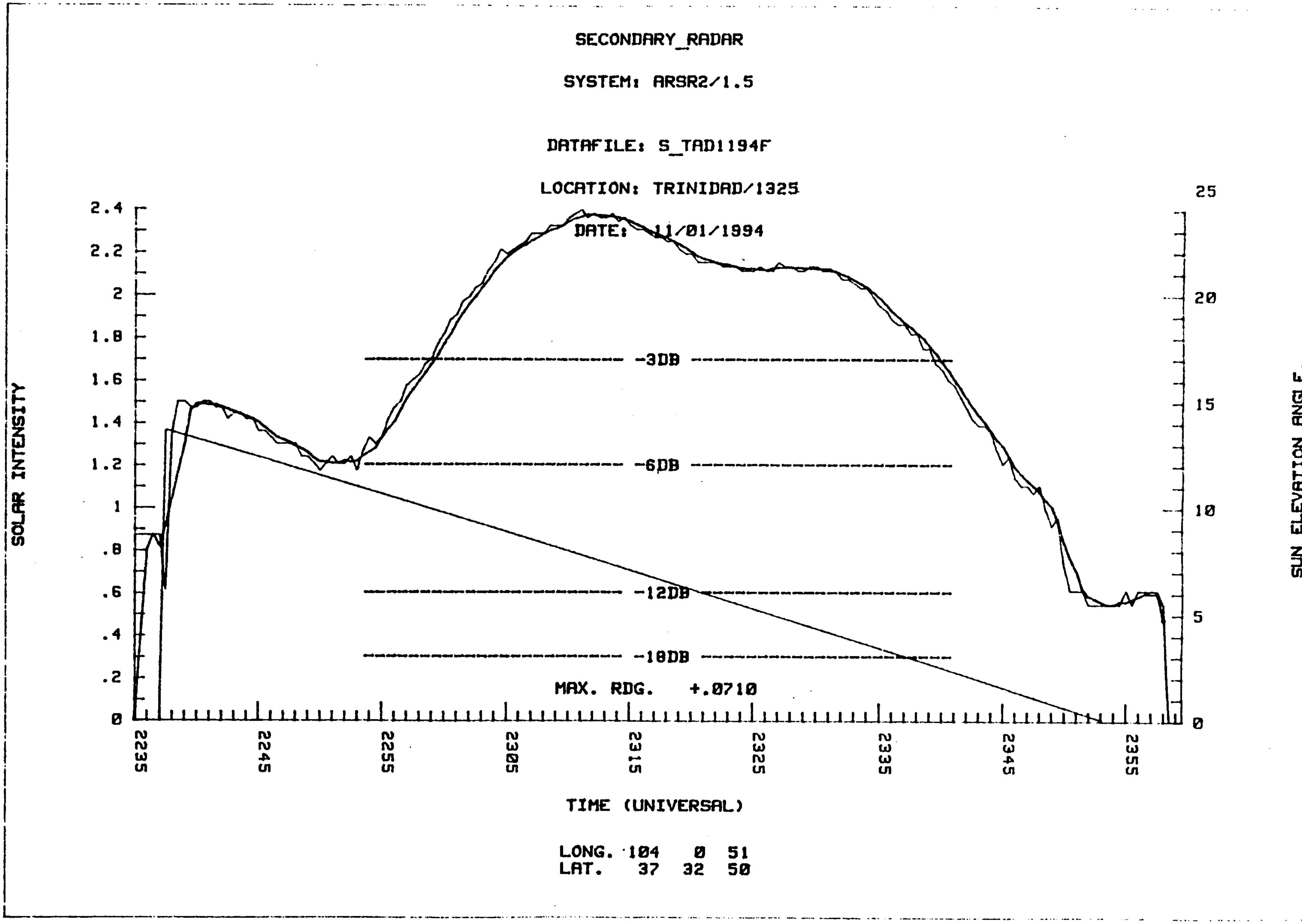
23 x10^-6

DEG. ELEV.



EVALUATE TILT AT 1.5

LOCATION TRINIDAD/1325


SECONDARY_RADAR
SYSTEM: ARSR2/1.5
DATAFILE: S_TAD1194F
LOCATION: TRINIDAD/1325
DATE: 11/01/1994
-3DB
-6DB
-12DB
-18DB
MAX. RDG. +.0710
SOLAR INTENSITY
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
SUN ELEVATION ANGLE.
25
20
15
10
5
0
2235
2245
2255
2305
2315
2325
2335
2345
2355
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50

DATAFILE: S_TAD1194F

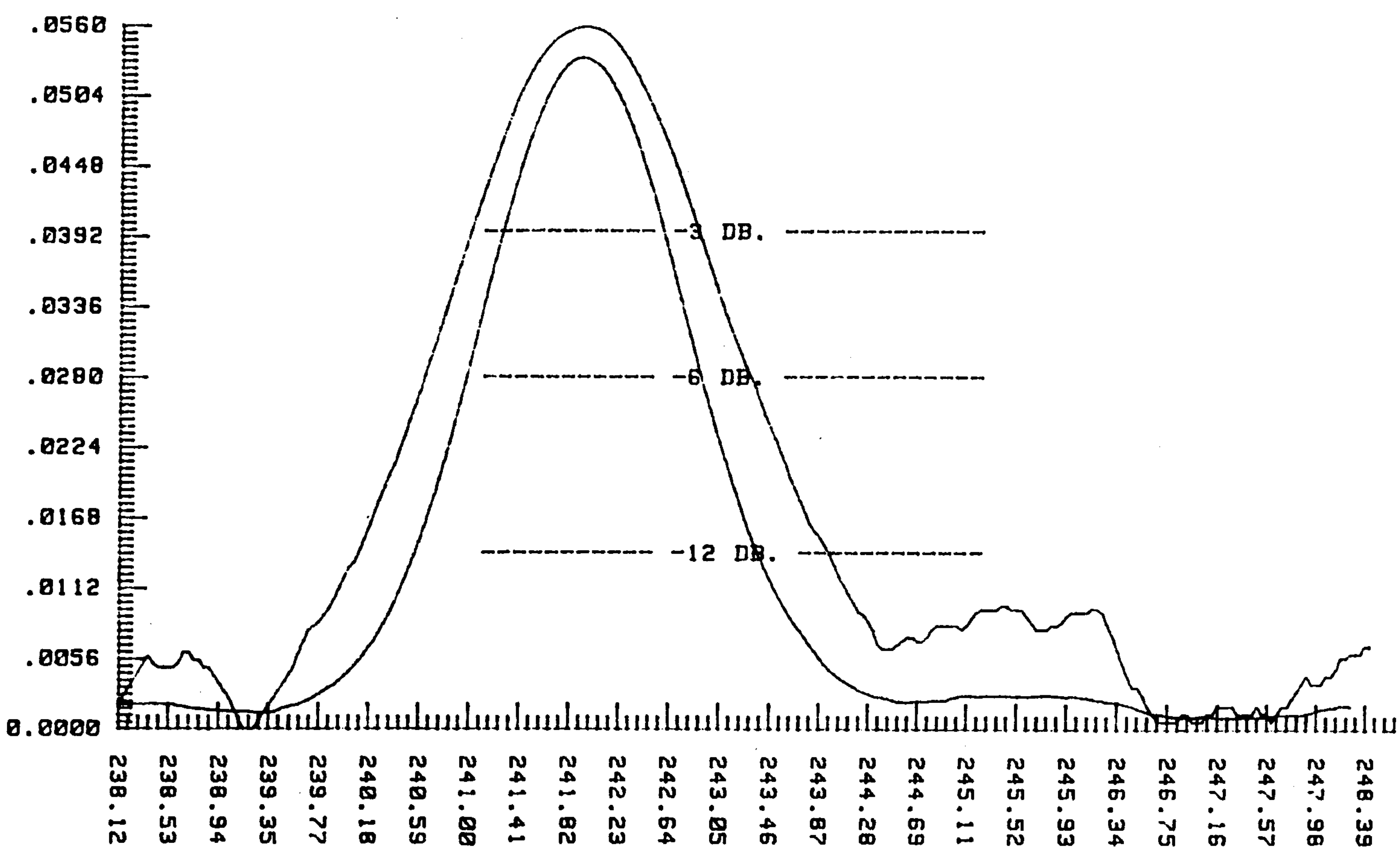
DATE: 11/01/1994

AZIMUTHAL CUT

COMPUTED AZ 247.19

SYSTEM TYPE: ARSR2/1.5

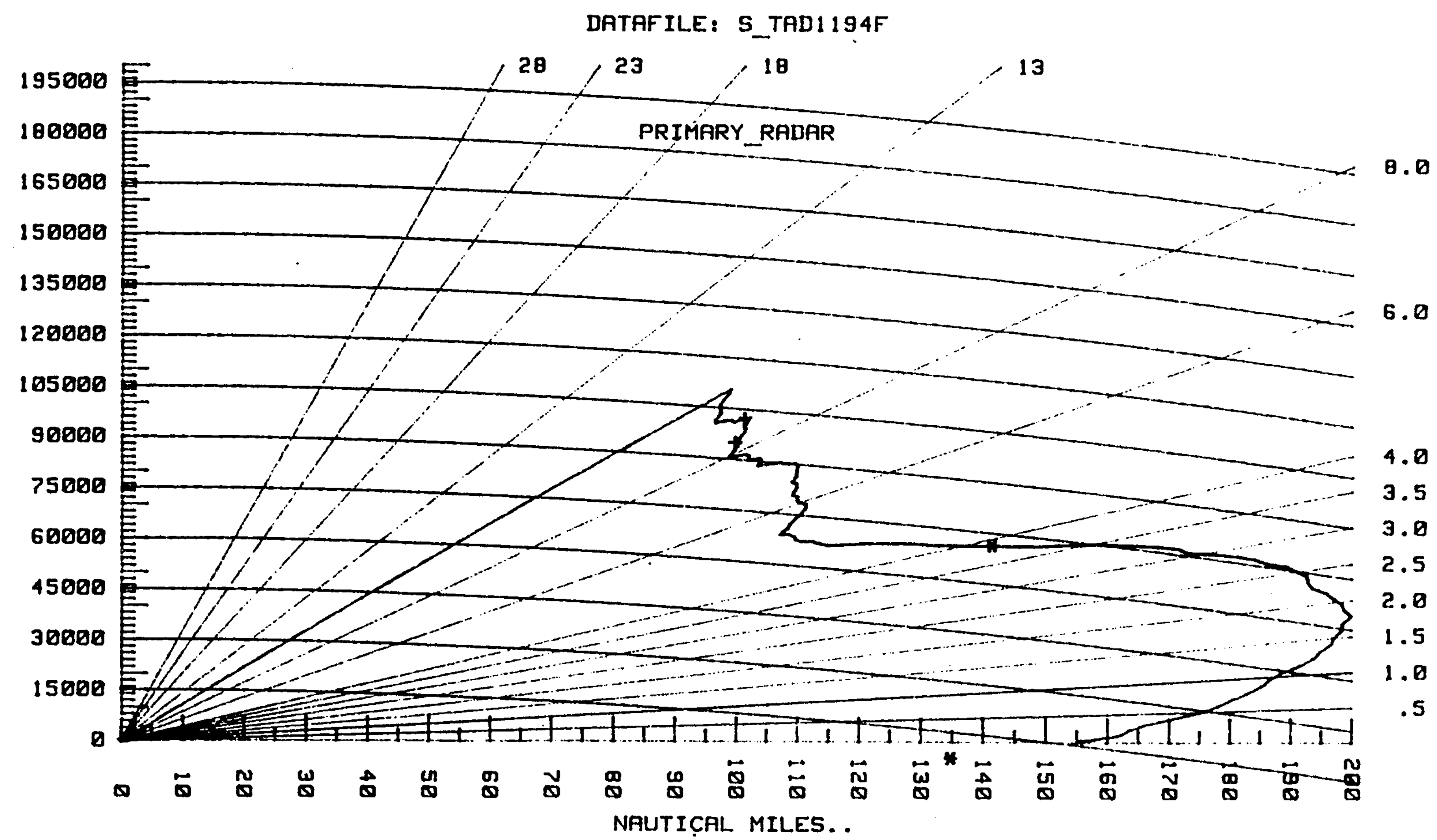
SCAN PERIOD: 9.58 SEC.



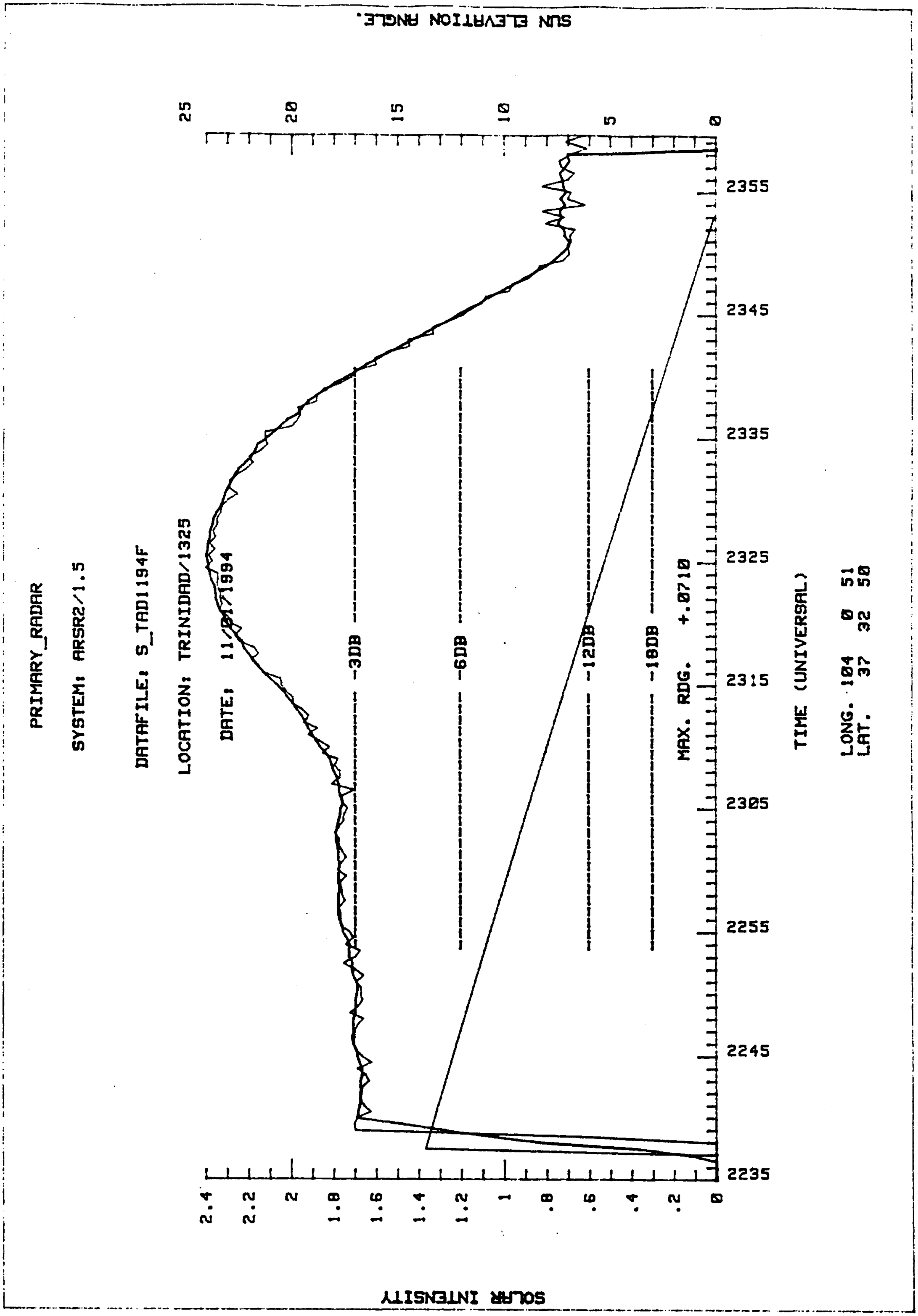
3 DB. B/W 1.85 DEG. ---- AZ. DEGREES...---- 6 DB. B/W 2.71 DEG.

TRINIDAD/1325

ANTENNA ELECTRICAL TILT IS 1.78 Deg
3DB points are at 3.87 AND -.33 Deg
6DB points are at 8.81 AND 8.29 Deg
3DB BANDWIDTH = 4.20 Deg

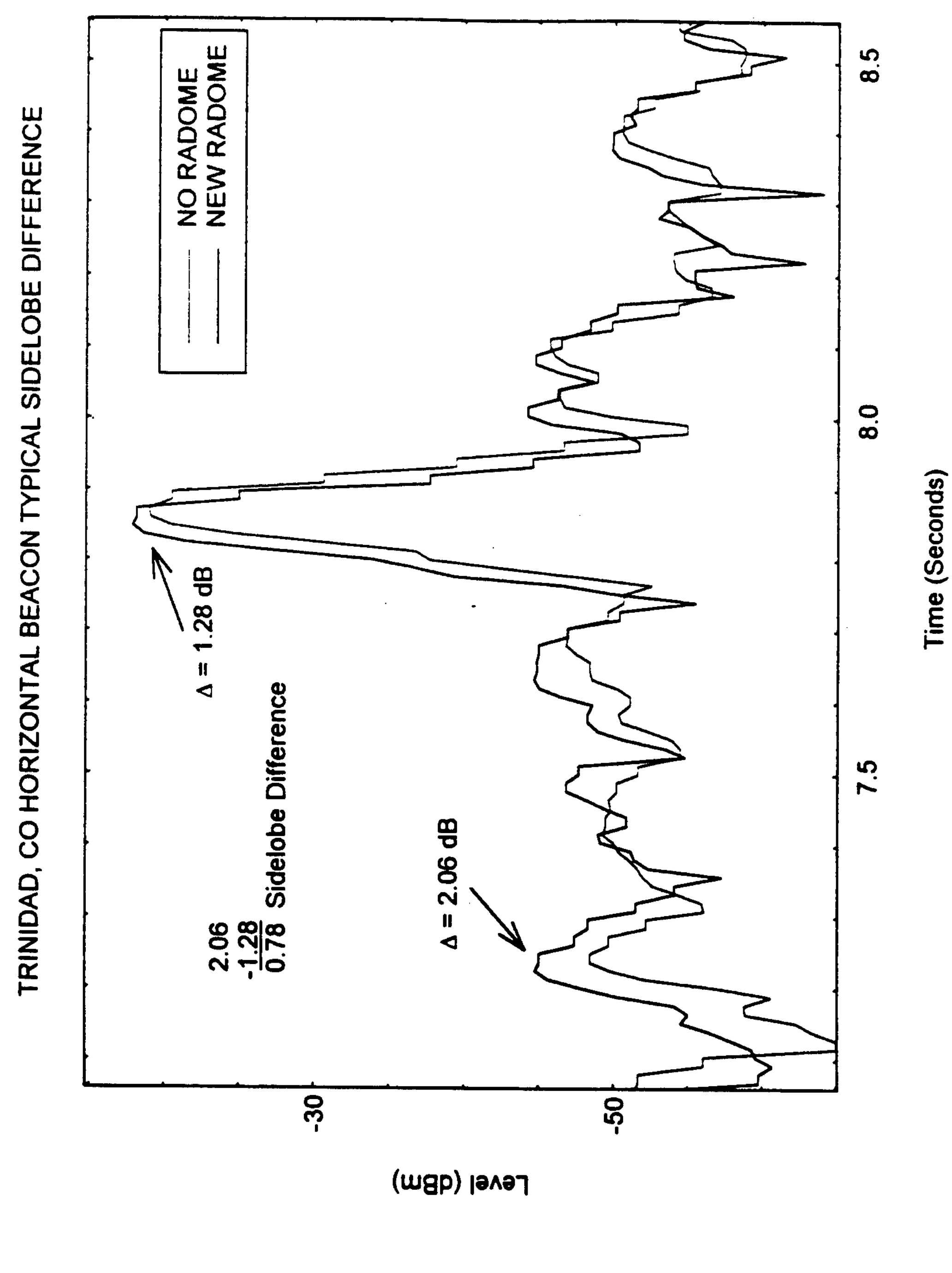


EVALUATE TILT AT 1.5
LOCATION TRINIDAD/1325


PRIMARY_RADAR
SYSTEM: ARSR2/1.5
DATAFILE: S_TAD1194F
LOCATION: TRINIDAD/1325
DATE: 11/04/1994
MAX. RDG. +.0710
-3DB
-6DB
-12DB
-18DB
SUN ELEVATION ANGLE.
25
20
15
10
5
0
SOLAR INTENSITY
2.4
2.2
2
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
2235
2245
2255
2305
2315
2325
2335
2345
2355
TIME (UNIVERSAL)
LONG. 104 0 51
LAT. 37 32 50

ATTACHMENT 4

SIDELOBE DIFFERENCES


TRINIDAD, CO HORIZONTAL BEACON TYPICAL SIDELOBE DIFFERENCE
NO RADOME
NEW RADOME
Δ = 1.28 dB
Δ = 2.06 dB
2.06
-1.28
0.78 Sidelobe Difference
Level (dBm)
-30
-50
Time (Seconds)
7.5
8.0
8.5

APPENDIX H

REPORT

VERTICAL RADIATION PATTERN MEASUREMENT TESTING

TRINIDAD EN ROUTE RADAR FACILITY (TAD)

Memorandum

U.S. Department
of Transportation

Federal Aviation
Administration

Subject: Information: Radome Replacement Tests, Trinidad, Colorado

Date: 3/29/95

Reply to Ulm
Attn of: X2324

From: Jim Ulm, ANM-4641

To: Manager, ANM-464, Technical Support Section

The following is an update and amendment to the Trinidad, Colorado Radome Replacement Project testing, that occurred 11 October through 4 November 1994.

During the testing period, vertical radiation pattern measurements (solars) were performed with no radome in place and again with the new radome installed. The data was compared; however the typical differences between a morning and an evening solar and the differences between solars on successive days are greater than the limits specified by the program office. Therefore the only conclusion that we can make is that the new radome made no measurable difference in the vertical radiation pattern.

Jim Ulm
Spectrum Management Officer

APPENDIX I

REPORT

QARS DATA EVALUATION

DENVER ARTCC (ZDV) AFS

Memorandum

U. S. Department
of Transportation
Federal Aviation
Administration

DENVER (ARTCC) AIRWAY FACILITIES SECTOR
2211 - 17th Avenue
Longmont, Colorado 80501

Subject: **INFORMATION:** Evaluation of Radar Data from Trinidad, CO, ARSR

Date: DEC 22 1994

From: Acting Manager, Denver (ARTCC) AFS

Reply to Attn. of: Braslow: 303-651-4433

To: Manager, ACW-100

Installation of a new radome at the Trinidad, CO, long-range radar site was completed November 2. Following a successful flight check 2 weeks later, we began an in-depth analysis to determine whether the new structure had any significant or unusual effects on the radar site's operating performance.

In conducting our evaluation, we compared daily site performance parameters captured by the Quick Analysis of Radar Sites (QARS) program. Although we focused on parameters like Scans, Blip Scans, Search Reinforce, Azimuth Splits, Range Splits, Mode 3/A Validation and Reliability, Mode-C Validation and Reliability, we did consider QARS as a whole. We also relied on input from air traffic controllers and personnel at the Systems Maintenance Monitoring Console and at the site itself.

Based on our evaluation of data collected from October 9 through November 15, we concluded that the new radome had no distinguishable impact on the performance of the radar system at Trinidad. Meanwhile, data collected since our evaluation period confirms our conclusions. It should be noted that data collected during the installation period was not used in this analysis.

If you have any questions or comments concerning the information provided, please do not hesitate to contact Barry Braslow, Staff Engineer, Technical Support Office, at 303-651-4433.

John J. Humphries

John J. Humphries

APPENDIX J

REPORT

ELECTROMAGNETIC PERFORMANCE TESTING

ALBUQUERQUE ARTCC (ZAB) AFS

U.S. Department
of Transportation

Federal Aviation Administration

Memorandum

Subject: **INFORMATION:** Trinidad (TAD) Long Range Radar Radome Replacement Evaluation

Date: DEC 0 8 1994

From: Acting Manager, Albuquerque ARTCC AFS

Reply to Attn. of:

To: Associate Program Manager for Test, ACW-100B

As part of the Mode S project, the radome at Trinidad (TAD) radar was replaced. The national office requested that Albuquerque ARTCC (ZAB) compare TAD radar performance before and after the radome replacement to verify that there is no adverse impact to air traffic control. The comparison revealed some small differences, but nothing that should impact air traffic control. The following is a detailed summary of the comparison:

RARRE program runs were done for data collected on October 14, 1994, at 19:00z to 24:00z (before the radome was removed) and on November 25, 1994, at 20:00z to 24:00z (after the radome was installed). The radar was operating on the same radar and beacon channels at those times.

Overall, radar reinforcement was 64 percent before and 62 percent after the radome replacement. The difference was mostly in the 50 to 105 mile range. The radar reinforcement before the replacement was around 70 percent and afterwards was around 60 percent. At other ranges, the radar reinforcement was slightly better afterwards than before. It is possible that these small differences are due primarily to differences in traffic patterns at the time of the data recordings.

On the Altitude and Range plots, the radar coverage after the replacement was 1,000 to 2,000 feet worse (higher) than before replacement. The greatest difference was at long range.

The range of radar coverage was 187 nautical miles before the replacement and 185 miles after. This range is less than normal, a coverage of 200 nautical miles is more typical.

BFTA program runs were done on data recorded October 14, 1994, and November 3, 1994. On these dates, the radar was operating on the same beacon channels. Recordings before the radome replacement show 45 false targets in 177834 beacon returns for a rate of .025 percent. Recordings after the replacement show 35 false targets on 143408 beacon returns for a rate of .024 percent. These rates are extremely good. The composition of the splits was roughly similar except that there were fewer ring around splits on data recorded after the radome replacement.

A small amount of PRF interference is indicated 80 degrees from the site. The altitude of the false targets, around 29,000 feet and higher, indicate that the range of the interfering radar is perhaps 370 nautical miles from the radar. The false target rate due to these false targets is very low, and it occurred with equal frequency both before and after the radome replacement.

COMDIG program runs showed that the radar was performing at least as well after the radome replacement. There was a definite improvement in parrot azimuth deviation. The parrots were outside the 2 acp limit about 9 percent of the time on the data collected before the radome was replaced. On recordings done after the radome was replaced, only one parrot return in 1,500 was outside the 2 acp limit. It isn't clear if the radome is the cause of this, but it is a great improvement.

In conclusion, there were some small changes in radar performance when radar data collected before the radome replacement is compared to data collected afterwards. These changes are small and should not affect air traffic control. Some of the changes indicate improvement in radar performance.

If you should require additional information, please contact David Roop, Technical Support Staff, at (505) 856-4451.

for Joseph R. McGuire, Jr.

APPENDIX K

REPORT

ATCS QUESTIONNAIRE

DENVER ARTCC (ZDV)

REC'D ANM-500/501

JAN 9 1995

512

ACTION:
INFO: 510

U.S. Department of Transportation

Federal Aviation Administration

Memorandum

DENVER AIR ROUTE TRAFFIC CONTROL CENTER
2211 - 17th Avenue
Longmont, Colorado 80501

Subject: INFORMATION: Trinidad Radar Questionnaire

Date: JAN 05 1995

From: Air Traffic Manager, ZDV-1

Reply to Attn of:

To: Manager, Air Traffic Division, ANM-500

On November 17, 1994, the Trinidad radar questionnaire was distributed to the control room. Controller participation with this survey was voluntary. As of this date, no questionnaires have been completed and returned to us.

Airspace and Procedures specialists have conducted several discussion sessions with controllers in an attempt to assist in the data-gathering process. Basically, the radome replacement has been transparent. There has not been a reported increase in the incidence of ring-around, false targets, or code swaps.

In discussions with controllers about the questionnaire, most found the questionnaire too technical and too long. Some of the language used in the questionnaire is more pertinent to a radar technician than an en route controller.

If you have any questions concerning this subject or if we can be of any further assistance, please contact David Laschinger, Assistant Manager-Airspace & Procedures, at (303) 651-4205.

Donald R. Smith

Donald R. Smith

APPENDIX L

REPORT

FLIGHT CHECK

TRINIDAD EN ROUTE RADAR FACILITY (TAD)

FLIGHT CHECK REPORT
Trinidad, Colorado
ARSR-2, ATCBI-3

PURPOSE

This report will provide a summary of the flight check conducted on the ARSR-2 and ATCBI-3 radar systems at the Trinidad Long Range Radar Site (LRR). The objective of the flight check was to verify that the structural members of the newly installed radome do not attenuate, or cause reflections, faise target positions or ring-around of the beacon or radar signal.

This was not a commissioning flight check but a *special inspection* as described in paragraphs 215.3D (1) and (3) of the Flight Check Manual OA P 8200.1. The Trinidad radar/beacon systems were out of service during the radome installation, but not decertified.

The flight check to verify the new radome included an inbound aircraft flying at 15,600 feet MSL with an orbit around the radar site at 10 nautical mile radius and an altitude of 8,000 feet MSL. Previous flight check data from the Trinidad LRR was not available, so no comparison between the radar performance with the old radome and the new radome is possible.

The flight check was conducted on November 15, 1994. This report contains a written explanation of the flight check procedures, recorded data supporting the analysis, and a summary of the coverage observed.

ANALYSIS TOOLS

During the flight check three methods were used to collect information for later analysis. QARS data was recorded at the Denver Air Route Traffic Control Center (ARTCC) and analyzed by personnel at that location familiar with the software. Manual scoring was used to record the inclusion or absence of a radar or beacon target as displayed on the controller's display. Raw data was recorded by personnel at the Trinidad radar site using digitized output from the Common Digitizer (CD). The conclusions in this report were based on analysis of the manual scoring and CD data.

Manual scoring was performed by observing the presence or absence of a target painted on the controllers display at the Denver ARTCC. The manual score sheets have been included as pages A1-A3. Data in the left column of the manual scoring sheets indicates range increments in nautical miles from the radar site to the aircraft. Each of the columns

to the right list the presence of a target as "**1**" and absence as a "**0**", for each scan of the display as the aircraft traveled from one five mile range mark to the next. If the target reaches the next range ring before the last column, as is typical of a slower aircraft, new recordings are then entered on the next row starting in the first column. Since the display at the ARTCC was not able to provide a range ring, constant communications with the site provided an indication when each range threshold was passed. Additional numbers occasionally listed in the sweep columns provide a more precise range indication. The technician at the site could more precisely track the aircraft and relay this information to the manual scorer at the Denver ARTCC via telephone.

After the plane reached the cone of silence and began its orbital flight, the function of the left hand column on page A3 was changed to indicate the azimuth of the plane relative to true north. On this page the numbers listed in the sweep columns indicate the azimuth snapshots relative to true north. Also note the tedium of writing a "**1**" to indicate a target was displayed eventually reduced to just recording the azimuth if a target was displayed.

The polar plots and data indicated on pages B1 through B7 and C1 through C7 were recorded directly from the CD by the local radar site manager, Stephen Lucero, and reduced using the software analysis tool PLOTCD at the Northwest Mountain Regional Office in Renton, Washington. Pages B1 through B7 contain plots and data covering the inbound flight at 57.1° true and an altitude of 15,600 feet MSL while pages C1 through C7 contain plots and data covering the orbit at 10 NMi radius and 8,000 feet MSL.

The polar plots on pages B1 and C1 graphically describe the flight profile during the investigation. while pages B2 and C2 are expanded images of the areas of interest. The following symbols are used to indicate which radar(s) had tracked the aircraft for each scan in the graphs:

- □ for a correlated radar and beacon return
- • for a radar only return
- □ for a beacon only return.

Pages B3 through B7 and C3 through C7 provide numerical data for each scan of the radar and beacon. A description of the data in each column is as follows:

SCAN Indicates a scan number relative to when the recording was started. Note the scan number does not start at zero because the target was not being tracked. Only the flight check aircraft with ID 2224 was analyzed for this report. All others were filtered out to improve clarity.

MSG Indicates which radars had received an acceptable return/reply.

FLAGS Indicates the altitude flag was recorded.

RNG Indicates the range to a resolution of 1/8s of a nautical mile.

AZ Indicates the azimuth in Azimuth Count Pulses (ACPs) from true north where azimuth in degrees = ACP / 4096 x 360°.

3/A Indicates the aircraft ID being recorded.

ALT Indicates the uncompensated altitude as recorded by the aircraft altimeter.
RL Indicates the Run Length (RL), or number of hits received while the target was in the main beam of the radar.
TIME Indicates the local time as programmed in the recording computer at Trinidad.
PORT Indicates the hardware recording port.
DELTA Indicates the Time between beacon messages.

PRE-FLIGHT BRIEFING

No pre-flight briefing was held with the flight check aircraft crew as they had reviewed the flight check plan sent to their operations headquarters prior to flight. Coordination with the Oklahoma FIFO, Denver ARTCC Air Traffic and airway facilities was completed prior to the start of the flight check, however. This coordination was used to brief the various elements of Air Traffic, airway facilities, flight check personnel and other interested parties in an attempt to understand the purpose of the flight check and the operational impacts and support required.

INBOUND CHECK

The flight check aircraft proceeded inbound to the Trinidad LRR at an altitude of 15,600 feet MSL over the LAMAR VORTAC at 57.1° true north. The aircraft was initially detected at a range of 133.1 nautical miles and was tracked inbound to the radar site until lost in the cone of silence at 2.04 nautical miles. As indicated in the plot on page B2 and data on pages B3-7, no unexpected jitter, drop-outs, or holes were observed that were considered significant.

ORBIT COVERAGE

The flight check aircraft then proceeded into a ten nautical mile orbit of the radar site at an altitude of 8,000 feet MSL. The orbit started at a bearing of 327° and ended at a bearing of 322°. During this time, the flight check aircraft was tracked by the ATCBI-3 system for the complete orbit. Primary tracking ceased because the MTI filters detected no radial velocity. No significant beacon false targets or ring around was noted which might indicate unusual or irregular attenuation or signal scattering from the radome support joints.

CONCLUSION

The flight check procedure was designed to place a target of known reflectivity, receptivity, and signal transmitting quality in various geometric configurations intended to provide insight into the insertion characteristics of the newly installed radome at the Trinidad, Colorado long range radar facility.

From the data collected and analyzed for this report, it has been determined the new radome exhibits negligible effects on the effectiveness of the radar systems it protects. For further copies of this report or a copy of the flight check plan, please contact Steve Walsh at (206-227-2977).

FAA Northwest Mountain Region

Beacon Scoring Sheet

Display

12°, MAG DEC

Facility (ZDV) TAD Date 11/15/?? Aircraft Saver

Route and Altitude

Beacon Channel ______ Dir Pk Power ______ watts Transponder power - High/Low

Ant Tilt Angle ______ Omni Pk Pwr ______ watts Transponder sensitivity - High/Low

Comments:

TAD- normal operation 2224 - Bcn ID

Inbound to TAD via LAMAR @ 15600 MSL 046°M/058 True

57.6°T

Sweep

Range*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
132	/	/	/																	
130	/	/	/	/	/															
125	/	/	/	/	/	/	/													
120	/	/	/	117/1	116/1															
115	/	115.4/1	114.8/1	113.2/1	112.12/1	111.16/1														
110,2	/	/	108/1	/	/	106.4/1	105/1													
104,12	/	103.16/1	/	101.20/1	/															
99,28	/	/	98.2/1	/	96,20/1	95,20/1														
95,0	/	/	93.16/1	/	91.28/1	/														
90.8	/	/	88.20/1	/	/	/														
85.12	/	/	/	83.0/1	82.0/1	81.12/1														
80.16	/	/	/	78.4/1	/	/														
75.2	/	/	74.4/1	/	72.16/1	/	- -													
70.28	/	/	/	68.16/1	/	66.24/1	66.0/1	65.8/1												
64.12	/	/	62.24/1	/	61.4/1	60.12/1	/													
58.24	/	/	57.4/1	/	55.16/1															
54.20	/	/	53.4/1	/	/															
50.20	/	/	49.0/1	/	/	46.20/1														
45.28	/	/	44.8/1	/	42.20/1	/														
41.0	/	/	40.0/1	/	36.28/1	/	/													
34.16	/	/	/	32.4/1	/	30.16/1														
30.0	/	/	28.0/1	/	/	25.20/1														

*Range to be recorded at 5 mile intervals.

(A-1)

FAA Northwest Mountain Region
Beacon Scoring Sheet

Page 2/3
Display

Facility ZDV TAD Date 11/15/94 Aircraft [illegible]
Route and Altitude
Beacon Channel ____ Dir Pk Power ____ watts Transponder power - High/Low
Ant Tilt Angle ____ Omni Pk Pwr ____ watts Transponder sensitivity - High/Low
Comments:

INBOUND to TAD [illegible] [illegible] 5100 MSL
[illegible]

Sweep

Range*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
24.24	/	/	23.0 /	/	21.20 /															
20.24	/	20.0 /	/	/	17.16 /	/														
16.0	/	15.4 /	14.12 /	13.16 /	/	12.0 /	/													
10.2	/	10.0 /	9.10 /	8.4 /	/	7.16 /	6.20 /	6.8 /												
5.20	/	5.04 /	4.16 /	3.28 /	3.12 /	2.48 /	2.12 /	—												

*Range to be recorded at 5 mile intervals

A-2

FAA Northwest Mountain Region
Beacon Scoring Sheet

Page 3/3
Display

Facility ZDV TAD Date 11/15/?? Aircraft
Route and Altitude
Beacon Channel Dir Pk Power watts Transponder power - High/Low
Ant Tilt Angle Omni Pk Pwr watts Transponder sensitivity - High/Low
Comments:

7600 FT

Sweep

BRG T ~~Range*~~	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
323	323 /	/	/	/																
315	/	/	~~[illegible]~~																	
310.26	/	307.26 /																		
304.28	/	300.94 /	297.77 /																	
294.35	/	290.58 /	287.32 /																	
283.71	/	280.19 /	276 /	272.17																
268.78	/	265.43	261.71																	
258.14	/	254.45	250.84	247.33	243.73	240.53	236.78	233.66	229.75	226.50										
222.89	/	219.38	216.74	212.59	209.01	205.43	201.89	198.05	194.59	191.08										
187.39	/	183.89	180.15	176.76	172.50	169.54	165.86	162.28	158.84	155.04										
151.52	/	147.84	144.32	140.72	136.73	133.60	130.00	126.48	122.79	119.22										
~~[illegible]~~	112.87	108.41	104.94	101.25	97.66	94.50	90.50	87.19	83.55	79.89										
76.47	72.86	69.05	65.83	62.32	59.59	55.28	52.48	48.60	45.35	42.19										
39.02	35.72	31.78	29.63	26.54	23.55	20.57	17.58	14.59	11.60	8.62										
5.63	2.46	359.13	355.88	352.42	349.19	345.[illegible]	342.14	338.64	334.98	331.05										
327.75																				

*Range to be recorded at 5 mile intervals

A-3

PLOTCD VERSION 68 (c)1992 PDS

FILENAME: FC1DATA.319

SCANS: 0 THROUGH 250

Mode 3/A Code 2224

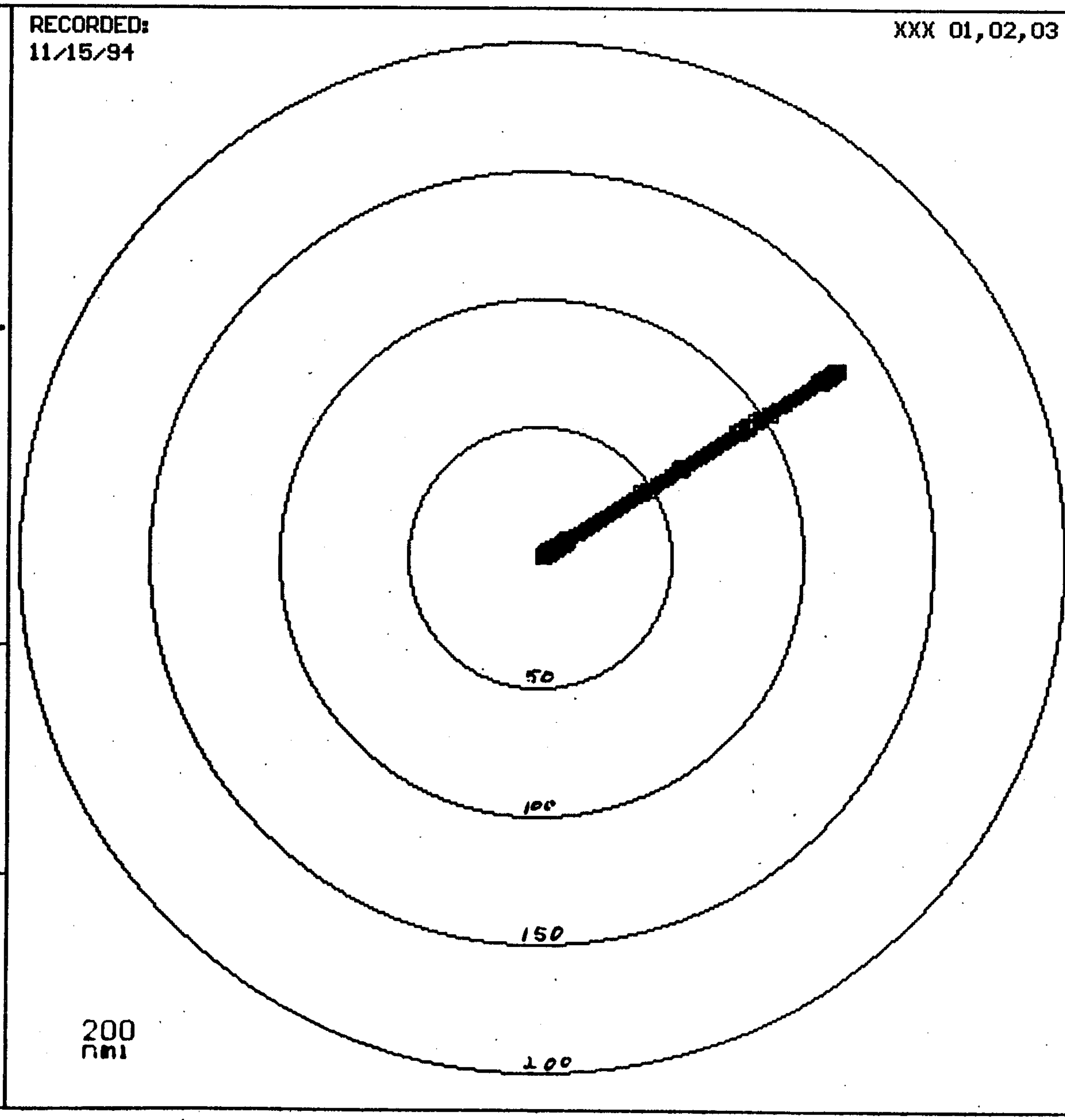
RdrBcn ▫ Enabled
Radar · Enabled
Beacon □ Enabled
WX ~ Disabled

Altitude = -1000 to 100000 ft.

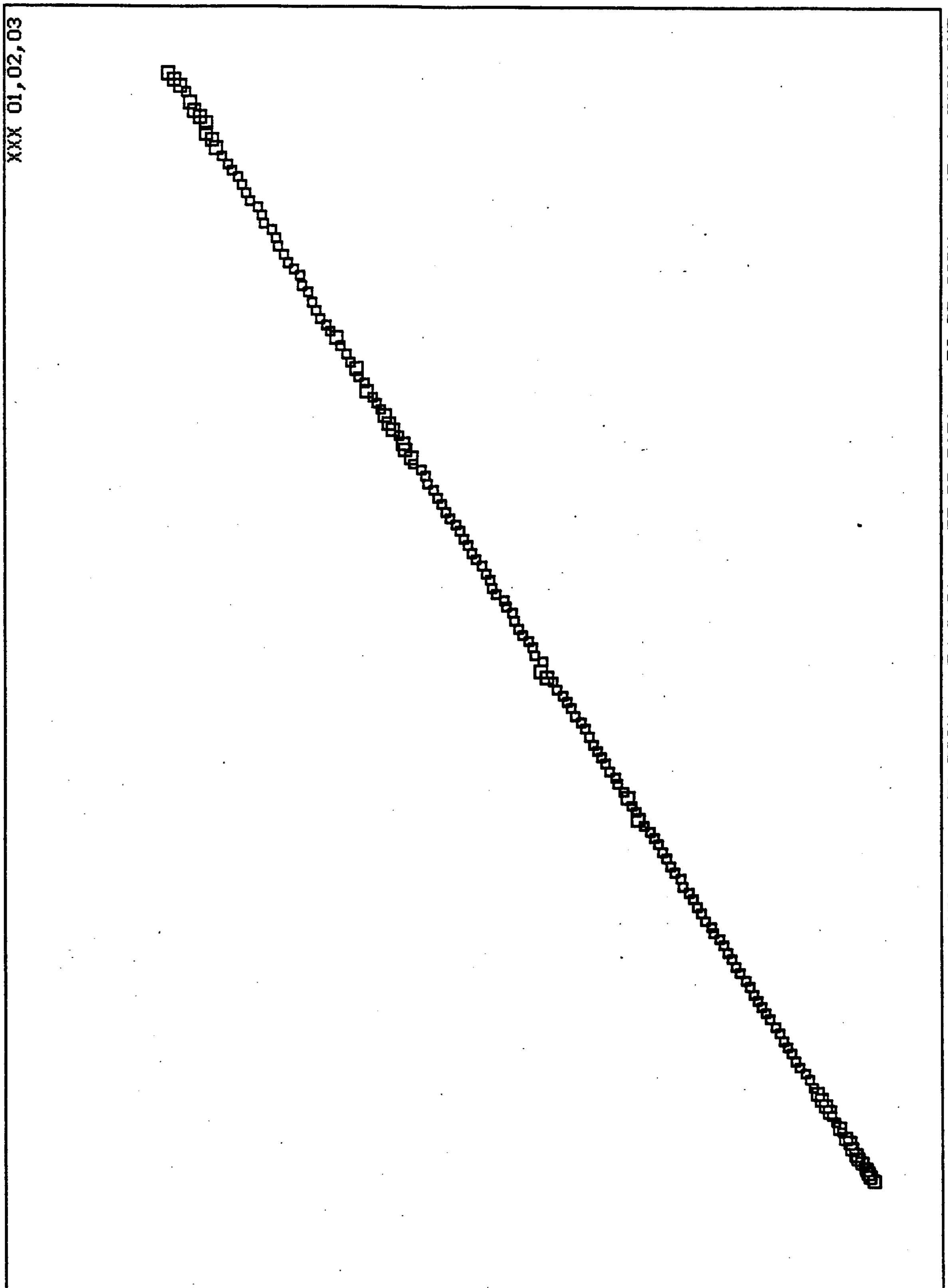
RdrBcn count = 126
Beacon count = 38
Radar count = 0
WX count = 0

Radar = 76.8 %
Reinforced

F1	FILE	Alt-F1	HELP
F2	ZOOM	Alt-F2	NOTE
F3	TARGET	Alt-F3	ID
F4	SCANS	Alt-F4	SETUP
F5	RANGE	Alt-F5	STATS
F9	PRINT	↕/↔	STEP
F10	QUIT		



B-1


XXX 01,02,03
FC1DATA.319
Scans: 0 to 250
F2-ZOOM
F6-DATA
F7-PR DATA
F9-PR SCRN
<Esc>-ZOOM OUT

B-2

CD RECORD 11/15/94 001 002 003 XXX 004 005 006 YYY

SCAN	MSG	FLAGS	RNG	AZ	3/A	ALT	RL	TIME	PORT	DELTA
53	BEACON		133/ 7	650	2224	15100	14	09:57:33.4	03	0.0
54	BEACON	3C	133/ 0	650	2224	15100	18	09:57:43.0	03	9.6
55	BEACON	3C	132/ 1	651	2224	15100	18	09:57:52.6	03	9.6
56	RDR/BCN	3C	131/ 2	652	2224	15100	20	09:58:02.0	02	9.4
57	BEACON	3C	130/ 2	651	2224	15100	20	09:58:11.8	01	9.8
58	BEACON	3C	129/ 3	651	2224	15100	18	09:58:21.3	01	9.5
59	BEACON	3C	128/ 4	652	2224	15100	20	09:58:31.0	02	9.7
60	BEACON	3C	127/ 5	652	2224	15100	24	09:58:40.5	02	9.5
61	BEACON	3C	126/ 6	650	2224	15100	22	09:58:50.1	02	9.6
62	BEACON	3C	125/ 7	651	2224	15100	22	09:58:59.7	03	9.6
63	BEACON	3C	125/ 0	650	2224	15100	26	09:59:09.3	01	9.6
64	RDR/BCN	3C	124/ 0	651	2224	15100	24	09:59:18.7	01	9.4
65	RDR/BCN	3C	123/ 1	651	2224	15100	26	09:59:28.3	02	9.6
66	RDR/BCN	3C	122/ 2	651	2224	15100	28	09:59:37.9	01	9.6
67	RDR/BCN	3C	121/ 3	652	2224	15100	30	09:59:47.5	03	9.6
68	RDR/BCN	3C	120/ 4	651	2224	15100	34	09:59:57.1	03	9.6
69	RDR/BCN	3C	119/ 5	651	2224	15100	34	10:00:06.7	01	9.6
70	RDR/BCN	3C	118/ 6	651	2224	15100	34	10:00:16.2	03	9.5
71	RDR/BCN	3C	117/ 6	652	2224	15100	30	10:00:25.9	03	9.7
72	RDR/BCN	3C	116/ 7	652	2224	15100	28	10:00:35.4	01	9.5
73	RDR/BCN	3C	116/ 0	651	2224	15100	28	10:00:45.0	01	9.6
74	RDR/BCN	3C	115/ 1	652	2224	15100	28	10:00:54.6	01	9.6
75	RDR/BCN	3C	114/ 2	652	2224	15100	30	10:01:04.2	03	9.6
76	RDR/BCN	3C	113/ 3	651	2224	15100	30	10:01:13.8	03	9.6
77	RDR/BCN	3C	112/ 3	651	2224	15100	30	10:01:23.4	02	9.6
78	RDR/BCN	3C	111/ 4	651	2224	15100	30	10:01:32.9	03	9.5
79	RDR/BCN	3C	110/ 5	651	2224	15100	28	10:01:42.5	01	9.6
80	RDR/BCN	3C	109/ 6	653	2224	15100	30	10:01:52.1	02	9.6
81	RDR/BCN	3C	108/ 7	651	2224	15100	32	10:02:01.6	02	9.5
82	RDR/BCN	3C	108/ 0	651	2224	15100	30	10:02:11.3	01	9.7
83	RDR/BCN	3C	107/ 0	650	2224	15100	32	10:02:20.8	01	9.5
84	RDR/BCN	3C	106/ 1	650	2224	15100	32	10:02:30.4	02	9.6
85	RDR/BCN	3C	105/ 2	649	2224	15100	30	10:02:40.0	02	9.6
86	RDR/BCN	3C	104/ 3	650	2224	15100	32	10:02:49.6	01	9.6
87	RDR/BCN	3C	103/ 4	651	2224	15100	30	10:02:59.3	02	9.7
88	BEACON	3C	102/ 5	652	2224	15100	30	10:03:08.8	01	9.5
89	RDR/BCN	3C	101/ 6	651	2224	15100	28	10:03:18.3	01	9.5
90	RDR/BCN	3C	100/ 6	651	2224	15100	30	10:03:27.9	01	9.6
91	RDR/BCN	3C	99/ 7	651	2224	15100	30	10:03:37.5	02	9.6
92	BEACON	3C	99/ 0	652	2224	15100	26	10:03:47.2	01	9.7
93	RDR/BCN	3C	98/ 2	651	2224	15100	30	10:03:56.7	03	9.5
94	RDR/BCN	3C	97/ 3	651	2224	15100	30	10:04:06.2	03	9.5
95	BEACON	3C	96/ 5	650	2224	15100	32	10:04:15.9	01	9.7
96	RDR/BCN	3C	95/ 7	651	2224	15100	30	10:04:25.3	02	9.4
97	RDR/BCN	3C	95/ 0	651	2224	15100	28	10:04:34.9	02	9.6
98	RDR/BCN	3C	94/ 2	651	2224	15100	28	10:04:44.6	01	9.7
99	BEACON	3C	93/ 4	652	2224	15100	28	10:04:54.2	01	9.6
100	BEACON	3C	92/ 5	651	2224	15100	28	10:05:03.8	03	9.6
101	BEACON	3C	91/ 7	651	2224	15100	30	10:05:13.4	01	9.6
102	RDR/BCN	3C	91/ 1	652	2224	15100	30	10:05:22.9	03	9.5
103	BEACON	3C	90/ 2	652	2224	15100	30	10:05:32.6	02	9.7
104	BEACON	3C	89/ 4	651	2224	15100	30	10:05:42.1	01	9.5
105	BEACON	3C	88/ 5	651	2224	15100	30	10:05:51.7	03	9.6
106	RDR/BCN	3C	87/ 7	650	2224	15100	30	10:06:01.2	01	9.5
107	RDR/BCN	3C	87/ 0	652	2224	15100	30	10:06:10.8	03	9.6

B-3

108	RDR/BCN	3C	86/ 2	652	2224	15100	30	10:06:20.4	01	9.6
109	RDR/BCN	3C*	85/ 3	651	2224	15100	30	10:06:30.0	03	9.6
110	RDR/BCN	3C	84/ 5	652	2224	15100	34	10:06:39.6	03	9.6

B-4

CD RECORD 11/15/94 001 002 003 XXX 004 005 006 YYY

SCAN	MSG	FLAGS	RNG	AZ	3/A	ALT	RL	TIME	PORT	DELTA
111	RDR/BCN	3C	83/ 6	651	2224	15100	32	10:06:49.1	03	9.5
112	RDR/BCN	3C	83/ 0	652	2224	15100	32	10:06:58.7	01	9.6
113	RDR/BCN	3C	82/ 1	651	2224	15100	34	10:07:08.3	01	9.6
114	RDR/BCN	3C	81/ 3	652	2224	15100	32	10:07:17.9	02	9.6
115	RDR/BCN	3C	80/ 4	653	2224	15100	34	10:07:27.5	02	9.6
116	RDR/BCN	3C	79/ 6	652	2224	15100	30	10:07:37.0	03	9.5
117	RDR/BCN	3C	78/ 7	651	2224	15100	34	10:07:46.6	01	9.6
118	RDR/BCN	3C	78/ 1	652	2224	15100	34	10:07:56.2	03	9.6
119	RDR/BCN	3C	77/ 2	652	2224	15100	34	10:08:05.8	02	9.6
120	RDR/BCN	3C	76/ 4	652	2224	15100	30	10:08:15.4	02	9.6
121	RDR/BCN	3C	75/ 5	652	2224	15100	32	10:08:24.9	03	9.5
122	RDR/BCN	3C	74/ 7	652	2224	15100	30	10:08:34.5	01	9.6
123	RDR/BCN	3C	74/ 1	652	2224	15100	32	10:08:44.1	03	9.6
124	RDR/BCN	3C	73/ 2	651	2224	15100	28	10:08:53.7	02	9.6
125	RDR/BCN	3C	72/ 4	651	2224	15100	30	10:09:03.3	03	9.6
126	RDR/BCN	3C	71/ 5	653	2224	15100	32	10:09:12.9	02	9.6
127	RDR/BCN	3C	70/ 7	652	2224	15100	32	10:09:22.4	01	9.5
128	RDR/BCN	3C	70/ 0	654	2224	15100	28	10:09:32.0	03	9.6
129	RDR/BCN	3C	69/ 2	651	2224	15100	36	10:09:41.6	03	9.6
130	RDR/BCN	3C	68/ 3	651	2224	15100	34	10:09:51.2	01	9.6
131	RDR/BCN	3C	67/ 5	651	2224	15100	36	10:10:00.8	01	9.6
132	RDR/BCN	3C	66/ 6	652	2224	15100	36	10:10:10.4	01	9.6
133	RDR/BCN	3C*	66/ 0	652	2224	15100	38	10:10:19.9	01	9.5
134	RDR/BCN	3C	65/ 2	651	2224	15100	36	10:10:29.5	03	9.6
135	RDR/BCN	3C	64/ 3	653	2224	15000	38	10:10:39.1	03	9.6
136	BEACON	3C	63/ 5	646	2224	15100	44	10:10:48.8	03	9.7
137	BEACON	3C	62/ 6	648	2224	15100	40	10:10:58.4	03	9.6
138	RDR/BCN	3C	62/ 0	651	2224	15100	38	10:11:07.8	03	9.4
139	RDR/BCN	3C	61/ 1	651	2224	15100	38	10:11:17.4	01	9.6
140	RDR/BCN	3C	60/ 3	652	2224	15100	38	10:11:27.0	01	9.6
141	RDR/BCN	3C	59/ 4	652	2224	15100	36	10:11:36.6	03	9.6
142	RDR/BCN	3C	58/ 6	652	2224	15100	38	10:11:46.2	01	9.6
143	RDR/BCN	3C	57/ 7	652	2224	15100	38	10:11:55.8	03	9.6
144	RDR/BCN	3C	57/ 1	653	2224	15100	36	10:12:05.3	03	9.5
145	RDR/BCN	3C	56/ 2	654	2224	15100	36	10:12:14.9	03	9.6
146	RDR/BCN	3C	55/ 4	653	2224	15100	38	10:12:24.5	01	9.6
147	RDR/BCN	3C	54/ 5	652	2224	15100	40	10:12:34.1	01	9.6
148	RDR/BCN	3C	53/ 7	653	2224	15100	36	10:12:43.7	03	9.6
149	RDR/BCN	3C	53/ 1	653	2224	15100	36	10:12:53.3	03	9.6
150	RDR/BCN	3C	52/ 2	653	2224	15100	36	10:13:02.8	02	9.5
151	RDR/BCN	3C	51/ 4	652	2224	15100	34	10:13:12.4	01	9.6
152	RDR/BCN	3C	50/ 5	654	2224	15100	36	10:13:22.0	03	9.6
153	RDR/BCN	3C	49/ 7	652	2224	15100	38	10:13:31.6	02	9.6
154	RDR/BCN	3C	49/ 0	653	2224	15100	36	10:13:41.2	01	9.6
155	BEACON	3C	48/ 2	654	2224	15100	36	10:13:50.8	03	9.6
156	RDR/BCN	3C	47/ 3	653	2224	15100	30	10:14:00.3	03	9.5
157	RDR/BCN	3C	46/ 5	652	2224	15100	36	10:14:09.9	02	9.6
158	BEACON	3C	45/ 7	649	2224	15100	22	10:14:19.6	02	9.7
159	RDR/BCN	3C	45/ 0	652	2224	15100	38	10:14:29.1	03	9.5
160	RDR/BCN	3C	44/ 2	653	2224	15100	34	10:14:38.7	03	9.6
161	RDR/BCN	3C	43/ 3	653	2224	15100	34	10:14:48.2	02	9.5
162	RDR/BCN	3C	42/ 5	653	2224	15100	38	10:14:57.8	03	9.6
163	RDR/BCN	3C	41/ 6	652	2224	15100	36	10:15:07.4	01	9.6
164	RDR/BCN	3C	41/ 0	652	2224	15100	34	10:15:17.0	01	9.6
165	RDR/BCN	3C	40/ 1	653	2224	15100	36	10:15:26.6	03	9.6

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166	RDR/BCN	3C	39/ 3	653	2224	15100	36	10:15:36.1	03	9.5
167	RDR/BCN	3C	38/ 4	654	2224	15100	36	10:15:45.7	02	9.6
168	RDR/BCN	3C	37/ 6	652	2224	15100	36	10:15:55.4	02	9.7

B-6

CD RECORD 11/15/94 001 002 003 XXX 004 005 006 YYY

SCAN	MSG	FLAGS	RNG	AZ	3/A	ALT	RL	TIME	PORT	DELTA
169	RDR/BCN	3C	36/ 7	653	2224	15100	36	10:16:04.9	01	9.5
170	RDR/BCN	3C	36/ 1	655	2224	15100	32	10:16:14.5	02	9.6
171	RDR/BCN	3C	35/ 2	653	2224	15100	36	10:16:24.1	01	9.6
172	RDR/BCN	3C	34/ 4	653	2224	15100	38	10:16:33.6	01	9.5
173	RDR/BCN	3C	33/ 5	653	2224	15100	38	10:16:43.2	03	9.6
174	RDR/BCN	3C	32/ 7	654	2224	15100	34	10:16:52.8	03	9.6
175	RDR/BCN	3C	32/ 1	653	2224	15100	36	10:17:02.4	02	9.6
176	RDR/BCN	3C	31/ 2	654	2224	15100	36	10:17:12.0	01	9.6
177	RDR/BCN	3C	30/ 4	655	2224	15100	34	10:17:21.5	01	9.5
178	RDR/BCN	3C	29/ 5	654	2224	15100	34	10:17:31.2	02	9.7
179	RDR/BCN	3C	28/ 7	654	2224	15100	36	10:17:40.7	02	9.5
180	RDR/BCN	3C	28/ 0	654	2224	15100	34	10:17:50.3	02	9.6
181	RDR/BCN	3C	27/ 2	653	2224	15100	36	10:17:59.9	03	9.6
182	RDR/BCN	3C	26/ 3	654	2224	15100	34	10:18:09.4	03	9.5
183	RDR/BCN	3C	25/ 5	655	2224	15100	36	10:18:19.0	03	9.6
184	RDR/BCN	3C	24/ 6	653	2224	15100	36	10:18:28.6	03	9.6
185	RDR/BCN	3C	24/ 0	655	2224	15100	36	10:18:38.2	03	9.6
186	RDR/BCN	3C	23/ 2	656	2224	15100	36	10:18:47.8	01	9.6
187	RDR/BCN	3C	22/ 3	654	2224	15100	36	10:18:57.4	01	9.6
188	RDR/BCN	3C	21/ 5	656	2224	15100	36	10:19:06.9	02	9.5
189	RDR/BCN	3C	20/ 6	656	2224	15100	36	10:19:16.6	02	9.7
190	RDR/BCN	3C	20/ 0	657	2224	15100	36	10:19:26.1	01	9.5
191	RDR/BCN	3C	19/ 1	657	2224	15100	38	10:19:35.7	03	9.6
192	RDR/BCN	3C	18/ 3	656	2224	15200	36	10:19:45.3	01	9.6
193	RDR/BCN	3C	17/ 4	657	2224	15200	36	10:19:54.8	01	9.5
194	RDR/BCN	3C	16/ 6	657	2224	15200	36	10:20:04.4	03	9.6
195	RDR/BCN	3C	16/ 0	658	2224	15200	36	10:20:13.9	02	9.5
196	RDR/BCN	3C	15/ 1	659	2224	15200	36	10:20:23.6	03	9.7
197	RDR/BCN	3C	14/ 3	659	2224	15200	36	10:20:33.2	03	9.6
198	RDR/BCN	3C	13/ 4	661	2224	15200	34	10:20:42.8	01	9.6
199	BEACON	3C	12/ 6	659	2224	15200	34	10:20:52.5	03	9.7
200	BEACON	3C	12/ 0	660	2224	15200	40	10:21:02.0	01	9.5
201	BEACON	3C	11/ 2	663	2224	15200	34	10:21:11.6	01	9.6
202	BEACON	3C	10/ 5	665	2224	15200	26	10:21:21.2	01	9.6
203	RDR/BCN	3C	10/ 0	666	2224	15200	42	10:21:30.7	03	9.5
204	RDR/BCN	3C	9/ 3	668	2224	15200	42	10:21:40.3	01	9.6
205	BEACON	3C	8/ 6	666	2224	15200	42	10:21:50.0	03	9.7
206	RDR/BCN	3C	8/ 1	671	2224	15200	42	10:21:59.5	02	9.5
207	BEACON	3C	7/ 4	672	2224	15200	42	10:22:09.1	01	9.6
208	BEACON	3C	6/ 7	671	2224	15200	42	10:22:18.7	01	9.6
209	BEACON	3C	6/ 2	673	2224	15200	36	10:22:28.3	03	9.6
210	BEACON	3C	5/ 5	675	2224	15200	40	10:22:37.9	02	9.6
211	BEACON	3C	5/ 1	680	2224	15200	40	10:22:47.5	02	9.6
212	BEACON	3C	4/ 4	682	2224	15200	30	10:22:57.1	03	9.6
213	BEACON	3C	3/ 7	690	2224	15200	30	10:23:06.6	03	9.5
214	BEACON	3C	3/ 3	696	2224	15200	28	10:23:16.2	01	9.6
215	BEACON	3C	2/ 7	705	2224	15200	18	10:23:25.9	03	9.7
216	BEACON	3C	2/ 3	724	2224	15200	28	10:23:35.5	03	9.6
216	BEACON	3C	2/ 3	724	2224	15200	28	10:23:35.5	03	0.0

B-7

PLOTCD VERSION 68
(c)1992 PDS

FILENAME: FCDATA.319

SCANS: 0 THROUGH 250

Mode 3/A Code 2224

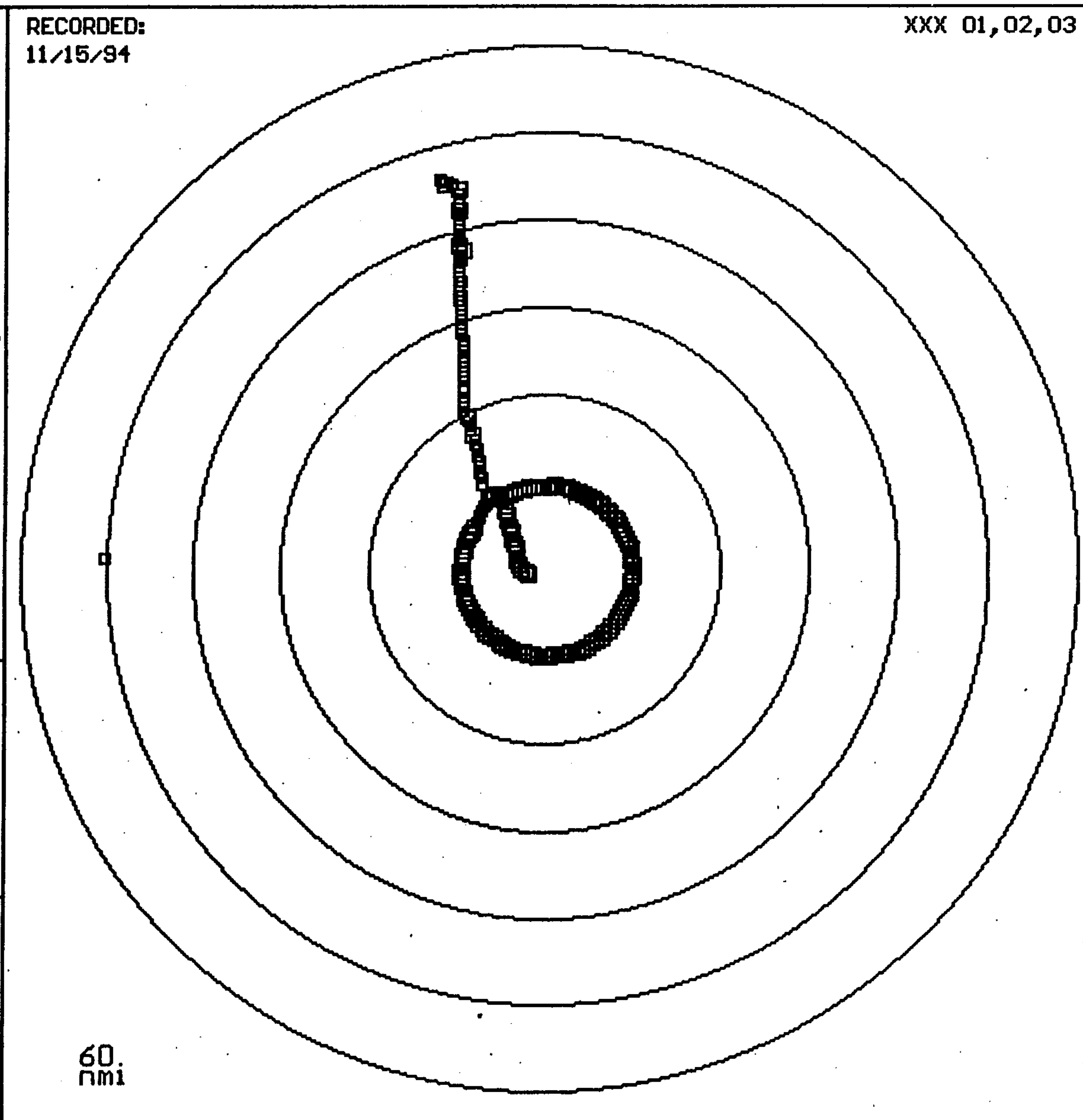
RdrBcn ▫ Enabled
Radar · Enabled
Beacon □ Enabled
WX ~ Disabled

Altitude = -1000 to 100000 ft.

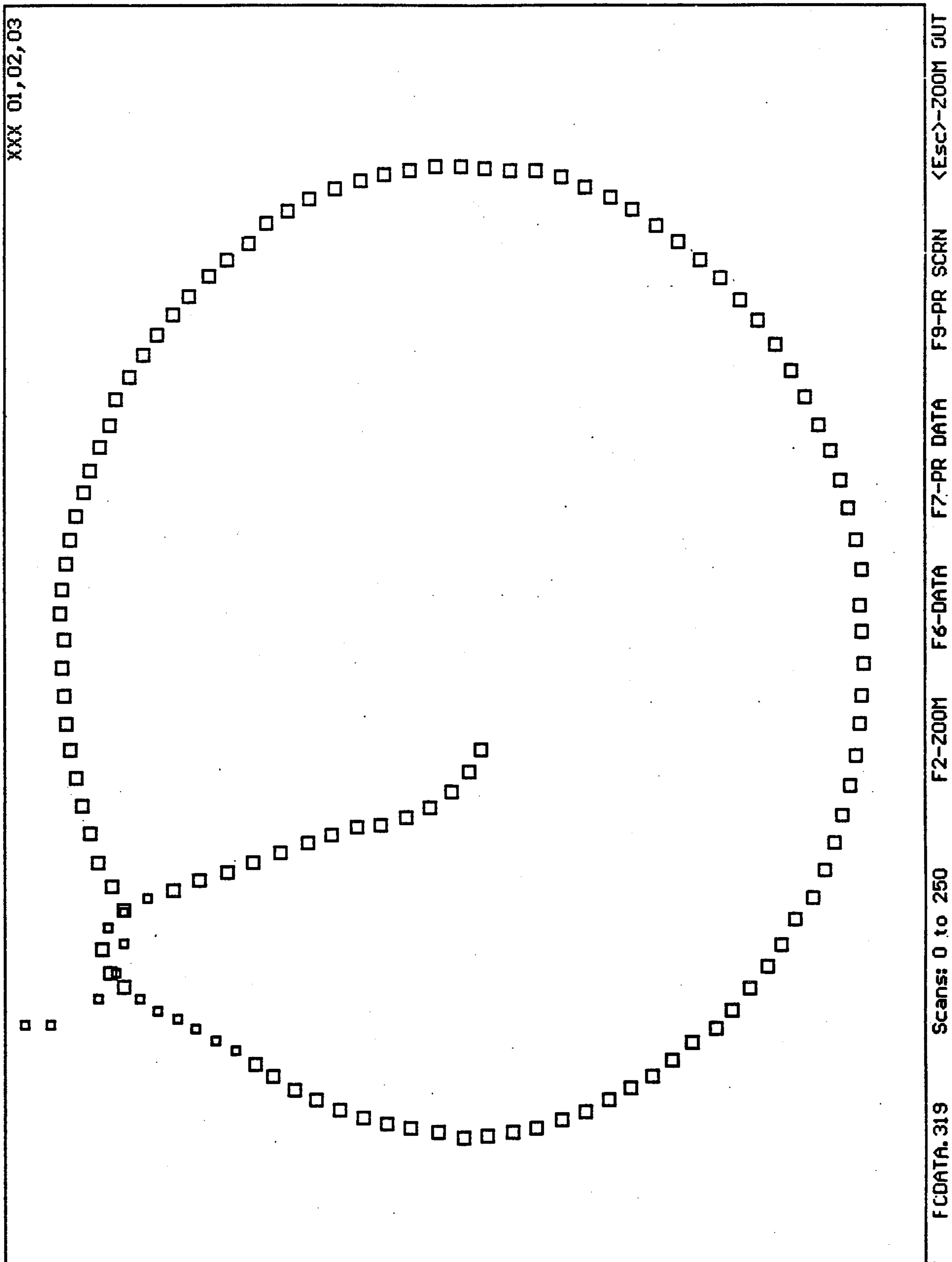
RdrBcn count = 71
Beacon count = 121
Radar count = 0
WX count = 0

Radar = 37.0 %
Reinforced

F1	FILE	Alt-F1	HELP
F2	ZOOM	Alt-F2	NOTE
F3	TARGET	Alt-F3	ID
F4	SCANS	Alt-F4	SETUP
F5	RANGE	Alt-F5	STATS
F9	PRINT	+/-	STEP
F10	QUIT		



C-1


XXX 01,02,03
FCDATA.319 Scans: 0 to 250 F2-ZOOM F6-DATA F7-PR DATA F9-PR SCRN <Esc>-ZOOM OUT

C-2

CD RECORD 11/15/94 001 002 003 XXX 004 005 006 YYY

SCAN	MSG	FLAGS	RNG	AZ	3/A	ALT	RL	TIME	PORT	DELTA
3	BEACON	3C	1/ 7	2845	2224	14100	42	10:24:36.8	03	0.0
4	BEACON	3C	2/ 2	2975	2224	13600	24	10:24:46.7	02	9.9
5	BEACON	3C	2/ 5	3097	2224	13100	28	10:24:56.5	01	9.8
6	BEACON	3C	3/ 0	3208	2224	12800	32	10:25:06.4	01	9.9
7	BEACON	3C	3/ 3	3311	2224	12400	36	10:25:16.2	02	9.8
8	BEACON	3C	3/ 6	3401	2224	12000	42	10:25:26.0	02	9.8
9	BEACON	3C	4/ 1	3476	2224	11600	44	10:25:35.8	01	9.8
10	BEACON	3C	4/ 5	3535	2224	11100	36	10:25:45.5	01	9.7
11	BEACON	3C	5/ 1	3580	2224	10400	40	10:25:55.1	01	9.6
12	BEACON	3C	5/ 6	3614	2224	9800	42	10:26:04.9	02	9.8
13	BEACON	3C	6/ 3	3644	2224	9200	36	10:26:14.5	03	9.6
14	BEACON	3C	7/ 0	3669	2224	8700	36	10:26:24.1	03	9.6
15	BEACON	3C	7/ 5	3691	2224	8300	36	10:26:33.8	01	9.7
16	BEACON	3C	8/ 2	3707	2224	7900	36	10:26:43.4	01	9.6
17	RDR/BCN	3C	8/ 7	3724	2224	7700	20	10:26:52.9	02	9.5
18	BEACON	3C	9/ 4	3732	2224	7600	28	10:27:02.6	01	9.7
19	RDR/BCN	3C	10/ 0	3725	2224	7600	24	10:27:12.0	03	9.4
20	BEACON	3C	10/ 3	3706	2224	7600	18	10:27:21.7	02	9.7
21	BEACON	3C	10/ 4	3675	2224	7600	26	10:27:31.2	03	9.5
22	BEACON	3C	10/ 3	3648	2224	7500	36	10:27:40.7	03	9.5
23	RDR/BCN	3C	10/ 2	3621	2224	7400	36	10:27:50.2	01	9.5
24	RDR/BCN	3C	10/ 1	3591	2224	7400	36	10:27:59.7	01	9.5
25	RDR/BCN	3C	9/ 7	3562	2224	7600	32	10:28:09.2	03	9.5
26	RDR/BCN	3C	9/ 6	3530	2224	7600	36	10:28:18.7	01	9.5
27	RDR/BCN	3C	9/ 5	3496	2224	7600	36	10:28:28.2	01	9.5
28	RDR/BCN	3C	9/ 4	3462	2224	7600	28	10:28:37.7	02	9.5
29	BEACON	3C	9/ 4	3424	2224	7600	34	10:28:47.3	02	9.6
30	BEACON	3C	9/ 4	3388	2224	7600	34	10:28:56.8	02	9.5
31	BEACON	3C	9/ 4	3349	2224	7600	34	10:29:06.2	02	9.4
32	BEACON	3C	9/ 4	3309	2224	7600	34	10:29:15.7	01	9.5
33	BEACON	3C	9/ 4	3269	2224	7600	30	10:29:25.2	03	9.5
34	BEACON	3C	9/ 4	3228	2224	7600	34	10:29:34.7	01	9.5
35	BEACON	3C	9/ 4	3189	2224	7600	30	10:29:44.2	01	9.5
36	BEACON	3C	9/ 4	3148	2224	7600	30	10:29:53.7	01	9.5
37	BEACON	3C	9/ 4	3103	2224	7600	36	10:30:03.2	01	9.5
38	BEACON	3C	9/ 5	3058	2224	7600	36	10:30:12.6	02	9.4
39	BEACON	3C	9/ 5	3020	2224	7600	34	10:30:22.1	02	9.5
40	BEACON	3C	9/ 5	2978	2224	7600	36	10:30:31.6	01	9.5
41	BEACON	3C	9/ 5	2937	2224	7600	34	10:30:41.1	02	9.5
42	BEACON	3C	9/ 5	2895	2224	7600	36	10:30:50.6	02	9.5
43	BEACON	3C	9/ 5	2854	2224	7600	36	10:31:00.1	03	9.5
44	BEACON	3C	9/ 5	2814	2224	7600	34	10:31:09.5	03	9.4
45	BEACON	3C	9/ 5	2773	2224	7600	36	10:31:19.0	02	9.5
46	BEACON	3C	9/ 5	2735	2224	7600	30	10:31:28.5	01	9.5
47	BEACON	3C	9/ 5	2694	2224	7600	34	10:31:38.0	02	9.5
48	BEACON	3C	9/ 5	2655	2224	7600	34	10:31:47.5	03	9.5
49	BEACON	3C	9/ 6	2614	2224	7600	34	10:31:57.0	03	9.5
50	BEACON	3C	9/ 6	2577	2224	7600	30	10:32:06.5	02	9.5
51	BEACON	3C	9/ 6	2536	2224	7600	34	10:32:16.0	02	9.5
52	BEACON	3C	9/ 6	2496	2224	7600	32	10:32:25.5	03	9.5
53	BEACON	3C	9/ 6	2458	2224	7600	34	10:32:34.9	03	9.4
54	BEACON	3C	9/ 6	2418	2224	7600	36	10:32:44.5	01	9.6
55	BEACON	3C	9/ 7	2378	2224	7600	34	10:32:54.0	02	9.5
56	BEACON	3C	9/ 7	2335	2224	7600	28	10:33:03.5	03	9.5
57	BEACON	3C	9/ 7	2297	2224	7600	26	10:33:12.9	01	9.4

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58	BEACON	3C	9/ 7	2256	2224	7600	34	10:33:22.4	02	9.5
59	BEACON	3C	9/ 7	2214	2224	7600	36	10:33:31.9	03	9.5
60	BEACON	3C	9/ 7	2174	2224	7600	34	10:33:41.4	02	9.5

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CD RECORD 11/15/94 001 002 003 XXX 004 005 006 YYY

SCAN	MSG	FLAGS	RNG	AZ	3/A	ALT	RL	TIME	PORT	DELTA
61	BEACON	3C	9/ 7	2132	2224	7600	36	10:33:50.9	02	9.5
62	BEACON	3C	9/ 7	2093	2224	7600	34	10:34:00.4	02	9.5
63	BEACON	3C	9/ 7	2052	2224	7600	34	10:34:09.9	02	9.5
64	BEACON	3C	9/ 7	2010	2224	7600	34	10:34:19.4	02	9.5
65	BEACON	3C	9/ 7	1974	2224	7600	46	10:34:28.9	02	9.5
66	BEACON	3C	10/ 0	1928	2224	7600	34	10:34:38.3	03	9.4
67	BEACON	3C	10/ 0	1887	2224	7600	34	10:34:47.8	02	9.5
68	BEACON	3C	10/ 0	1845	2224	7600	36	10:34:57.3	02	9.5
69	BEACON	3C	10/ 0	1805	2224	7600	34	10:35:06.8	01	9.5
70	BEACON	3C	10/ 0	1764	2224	7600	34	10:35:16.3	01	9.5
71	BEACON	3C	10/ 0	1724	2224	7600	36	10:35:25.7	02	9.4
72	BEACON	3C	10/ 0	1682	2224	7600	34	10:35:35.3	02	9.6
73	BEACON	3C	10/ 0	1642	2224	7600	36	10:35:44.7	02	9.4
74	BEACON	3C	10/ 0	1601	2224	7600	32	10:35:54.2	02	9.5
75	BEACON	3C	10/ 0	1559	2224	7600	34	10:36:03.7	01	9.5
76	BEACON	3C	10/ 0	1520	2224	7600	34	10:36:13.2	02	9.5
77	BEACON	3C	10/ 0	1479	2224	7600	34	10:36:22.7	01	9.5
78	BEACON	3C	10/ 0	1439	2224	7600	36	10:36:32.1	03	9.4
79	BEACON	3C	10/ 0	1397	2224	7600	36	10:36:41.6	02	9.5
80	BEACON	3C	10/ 0	1357	2224	7600	34	10:36:51.1	02	9.5
81	BEACON	3C	10/ 0	1315	2224	7600	34	10:37:00.6	02	9.5
82	BEACON	3C	10/ 0	1275	2224	7600	36	10:37:10.1	03	9.5
83	BEACON	3C	10/ 0	1234	2224	7600	36	10:37:19.6	02	9.5
84	BEACON	3C	10/ 0	1194	2224	7600	34	10:37:29.1	03	9.5
85	BEACON	3C	10/ 0	1152	2224	7600	34	10:37:38.5	01	9.4
86	BEACON	3C	9/ 7	1111	2224	7600	34	10:37:48.0	02	9.5
87	BEACON	3C	9/ 7	1071	2224	7600	36	10:37:57.5	01	9.5
88	BEACON	3C	9/ 7	1033	2224	7600	28	10:38:07.0	02	9.5
89	BEACON	3C	9/ 7	992	2224	7600	24	10:38:16.5	01	9.5
90	BEACON	3C	9/ 7	950	2224	7600	36	10:38:26.0	03	9.5
91	BEACON	3C	9/ 7	909	2224	7600	36	10:38:35.5	01	9.5
92	BEACON	3C	9/ 7	870	2224	7600	30	10:38:44.9	03	9.4
93	BEACON	3C	9/ 7	829	2224	7600	34	10:38:54.4	01	9.5
94	BEACON	3C	9/ 7	786	2224	7600	28	10:39:03.9	03	9.5
95	BEACON	3C	9/ 7	749	2224	7600	36	10:39:13.4	02	9.5
96	BEACON	3C	9/ 7	709	2224	7600	34	10:39:22.9	03	9.5
97	BEACON	3C	9/ 6	670	2224	7600	34	10:39:32.4	02	9.5
98	BEACON	3C	9/ 6	630	2224	7600	34	10:39:41.9	01	9.5
99	BEACON	3C	9/ 6	593	2224	7600	36	10:39:51.4	02	9.5
100	BEACON	3C	9/ 6	554	2224	7600	36	10:40:00.9	01	9.5
101	BEACON	3C	9/ 6	516	2224	7600	34	10:40:10.3	03	9.4
102	BEACON	3C	9/ 6	480	2224	7600	36	10:40:19.8	02	9.5
103	BEACON	3C	9/ 6	444	2224	7600	34	10:40:29.3	01	9.5
104	BEACON	3C	9/ 6	407	2224	7600	36	10:40:38.8	01	9.5
105	BEACON	3C	9/ 6	372	2224	7600	36	10:40:48.3	02	9.5
106	BEACON	3C	9/ 5	337	2224	7600	34	10:40:57.8	01	9.5
107	BEACON	3C	9/ 5	302	2224	7600	36	10:41:07.3	01	9.5
108	BEACON	3C	9/ 5	268	2224	7600	36	10:41:16.9	02	9.6
109	BEACON	3C	9/ 5	234	2224	7600	36	10:41:26.4	02	9.5
110	BEACON	3C	9/ 5	200	2224	7600	36	10:41:35.9	03	9.5
111	BEACON	3C	9/ 5	166	2224	7600	36	10:41:45.4	02	9.5
112	BEACON	3C	9/ 5	132	2224	7600	36	10:41:54.9	03	9.5
113	BEACON	3C	9/ 5	98	2224	7600	36	10:42:04.4	03	9.5
114	BEACON	3C	9/ 5	64	2224	7600	36	10:42:13.9	01	9.5
115	BEACON	3C	9/ 4	28	2224	7600	36	10:42:23.3	02	9.4

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115	BEACON	3C	9/ 4	4086	2224	7600	34	10:42:32.9	02	9.6
116	BEACON	3C	9/ 4	4049	2224	7600	32	10:42:42.3	01	9.4
117	BEACON	3C	9/ 4	4010	2224	7600	36	10:42:51.9	01	9.6

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CD RECORD 11/15/94 001 002 003 XXX 004 005 006 YYY

SCAN	MSG	FLAGS	RNG	AZ	3/A	ALT	RL	TIME	PORT	DELTA
118	BEACON	3C	9/ 4	3973	2224	7600	34	10:43:01.3	02	9.4
119	BEACON	3C	9/ 4	3933	2224	7600	32	10:43:10.9	01	9.6
120	BEACON	3C	9/ 4	3893	2224	7600	34	10:43:20.3	01	9.4
121	BEACON	3C	9/ 4	3853	2224	7600	30	10:43:29.8	02	9.5
122	BEACON	3C*	9/ 4	3811	2224	7600	36	10:43:39.3	03	9.5
123	BEACON	3C	9/ 4	3770	2224	7600	36	10:43:48.8	01	9.5
124	RDR/BCN	3C	9/ 4	3729	2224	7600	36	10:43:58.2	02	9.4
125	RDR/BCN	3C	9/ 7	3694	2224	7600	32	10:44:07.7	02	9.5
126	RDR/BCN	3C	10/ 3	3670	2224	7600	36	10:44:17.2	03	9.5
127	RDR/BCN	3C	11/ 0	3661	2224	7600	34	10:44:26.7	03	9.5
129	RDR/BCN	3C	12/ 2	3678	2224	7600	32	10:44:46.0	02	19.3
130	RDR/BCN	3C	12/ 6	3696	2224	7600	30	10:44:55.6	01	9.6

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